40 plates.

TOBACCO

AND

ITS ADULTERATIONS.

TOBACCO

AND ITS

ADULTERATIONS;

WITH ILLUSTRATIONS DRAWN & ETCHED

BY

HENRY P. PRESCOTT,

OF THE INLAND REVENUE DEPARTMENT

LONDON.

JOHN VAN VOORST, PATERNOSTER ROW.

1858.

PREFACE.

THE following pages have been written for the purpose of assisting Officers of the Government, and others interested in the subject, in acquiring a knowledge of the characters of unmanufactured and manufactured Tobacco, and of enabling them to detect its impurities.

Among the adulterations which have from time to time been discovered in manufactured Tobacco, the following substances may be named :—Leaves of *Rhubarb*, *Dock*, *Burdock*, *Coltsfoot*, *Beech*, *Plantain*, *Oak*, and *Elm* ; *Peat-earth*, *Bran*, *Sawdust*, *Malt-rootlets*, *Barley-meal*, *Oat-meal*, *Bean-meal*, *Pea-meal*, *Potato-starch*, and *Chicory*-leaves steeped in tar-oil.

From the foregoing enumeration it will be evident that the object in view cannot be attained by the study

of Tobacco alone, and that, as the adulterating ingredients are for the most part derived from the Vegetable World, the structural peculiarities of the roots, stems, and leaves of other plants, and the forms of their constituent elements, require to be carefully studied.

The subjects illustrated have been selected from my note-book, principally with reference to the known adulterations of Tobacco. The leaves of some plants to which Tobacco is allied have been selected for the purpose of enabling the Student to compare their forms and structure, others on account of some resemblance which they bear to each other, and, as such, affording useful examples in the *method* of analysis which the book is intended to teach. A few leaves of plants possessing poisonous or medicinal qualities have also been introduced, in the belief that Students in Medicine who are making microscopical study a branch of their professional education will find the volume of some use. Collaterally, the Microscopist and the Physiologist may feel interested in the forms and structure of the *hairs* of leaves, whose uses in Nature's vast œconomy science has not yet explained.

To render the work more useful to those for whom it is chiefly intended, a concise description of the Construc-

tion of the Microscope, and its Management in the Examination of some Vegetable Tissues, has been added.

It has been my endeavour to dispense with scientific terms as much as possible; but in doing so there is a constant tendency to fall into a diffuse and indefinite method of expression. It is hoped therefore that the reader unacquainted with scientific language will not be scared by a few terms that may at first appear harsh, but rather that he will court that familiarity with them which a little patient study will be sure to bring.

To Sir William Hooker, Director of the Royal Gardens at Kew, and to Dr. Joseph Hooker, I am indebted for the liberal supply of fresh specimens of leaves, &c., from which my analyses and drawings have been made; to the latter gentleman especially my best thanks are tendered for many useful hints on the subject of botanical illustration.

To Mr. John Pye, whose name is so honourably associated with the best productions in the English school of landscape-engraving, my grateful acknowledgments are here offered for his valuable direction in the etching of the Plates,—friendly assistance which has contributed as largely to any merit they may possess, as it has lessened

my labour and anxiety in producing them. Beauty of delineation has been less aimed at than accuracy: something will be gained to the student if the freshness which alone pertains to life-studies has been preserved.

The authorities from whom information has been derived have, in every instance, been carefully cited. Where the name of Dr. Lindley appears, reference is intended either to that author's 'Vegetable Kingdom,' 'Medical and Œconomic Botany,' 'Elements of Botany,' or 'School Botany,'—works which have been frequently consulted.

HENRY P. PRESCOTT.

St. John's Wood,
July 1858.

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER VII.

TOBACCO

AND

ITS ADULTERATIONS.

CHAPTER I.

INTRODUCTION.

The various and beautiful organic structures contained in the Vegetable Kingdom have, many of them, important relations to the necessities and the luxuries of mankind. Foremost among these may be considered the all-important one of food, which vegetation furnishes, either directly to man himself, or indirectly to him, as the nourishment of those animals which he consumes. Cotton, a vegetable product; coal, also of vegetable origin; medicinal herbs, with their thousand applications to the alleviation of human pain; and tobacco, the narcotic indulgence, in a greater or less degree, of nearly the whole civilized globe, are so many illustrations of the manifold uses of plants and their products.

Not less wonderful than the beauty and symmetry of the outward forms of plants, are the wide distribution and enormous amount of organizing forces which they possess, enabling them (unlike the members of the animal kingdom) to throw out new

tissues from any part almost of their structure, and, by the rapidity with which these increase, to yield to man and animals an ample supply of useful material. Dr. Desaguliers, a French philosopher, ascertained, by careful experiment, that a turnip seed increased fifteen times its own weight in a minute, and the root fifteen thousand times its original weight per day*. Familiar instances of the enormous amount of vital force possessed by the seeds of plants are seen in the growth of them in moistened flannel, a medium sufficient to elicit this latent energy, and, for a time, to sustain it. The germination of grain in the malting process is another instance in which water and air exert a similar influence. The readiness with which plants throw out their tissues from almost any part of their structure, to form new plants, is taken advantage of by the gardener in his operations of "*cutting*" and "*grafting*:" in that of *layering*, as it is technically termed, he repeats a natural process constantly occurring during the growth of the Strawberry plant.

Nature does not perhaps exhibit a grander phenomenon for contemplation than the silent appropriation and assimilation by plants, of those gases which, either exhaled from the lungs of animals, or as the products of fermentation and putrefaction of decaying animal and vegetable matters, are continually floating in the atmosphere and prove injurious to animal life. Among these are carbonic acid and ammonia. In the assimilation of the carbon, and liberation of the oxygen of the carbonic acid by the leaves of plants, they may be considered so many laboratories wherein this gas is resolved into its constituent elements—a result which the profoundest chemist strives in vain to accomplish; in yielding oxygen, they return to the air its life-sustaining element. In their outward aspect, beauty of form, of texture, and of colour combine to render them most attractive objects.

* Lindley's Elements of Botany.

There is not a plant that grows but has its leaves formed on a fixed and definite plan; and in each plan may be distinctly traced a peculiarity of its own. The shape which leaves assume is, in some instances, of so marked a character as to enable us to predict with certainty the poisonous properties of the plant which has produced them; whilst the arrangement of their veins is a no less certain index of the internal structure of the stem on which they have grown, and even of the seed from which their parent plant has been derived. Thus the oak-leaf and the acorn alike inform us of the arrangement of the minutest fibres within the giant stem which has supported and matured them.

When the *structure* of a leaf is examined, it is found to be covered externally with a delicate transparent skin, or epidermis, on which are thickly clustered extensions of its cellular elements in the form of hairs, so minute that the quickest sight can only detect their presence as a soft downy substance, but in which the microscope reveals to us a forest of forms as various as the leaves on which they grow, and withal as true as they to their appointed symmetry. Lying scattered among these, again, are the pores (*stomates*), through which air and gases find their way to or from the interior of the leaf; and beneath these, cavities which conduct them to the inner laboratory, built up of numberless cells, in which they are decomposed or absorbed.

On examining the substance of some leaves, minute crystals, truly geometrical in their forms, are seen suspended in beautiful clusters from the ceiling of a cell, or lying in compact or scattered masses on the floor within it, in the form of delicate needle-shaped bodies, which become beautifully tinted with variegated colours under the action of polarized light. Or, again, myriads of starch-granules, differing in their forms according to the plant in which they are found, lie stored in the cells of their leaf-stalks, stems, and roots. From the extreme

delicacy of all these bodies, they elude any mechanical efforts to destroy their structure, however finely either leaf, stem, or root may be divided.

Taking, then, the definite characters which the external *form* and *venation* of leaves afford, and those *structural* peculiarities of them, and of the *stems* and *roots* of plants, which the microscope exhibits to us, it will be seen that there exists abundant evidence of what is, and of what is not, "Tobacco," and that if, by the substitution of the spurious for the genuine, our senses are at times imposed upon, it is because we have neither examined nor studied those signs which here, as in her other works, Nature offers continually to our view, serving as infallible guides in the search after Truth,—and, it may be added, evidences of that Power and Wisdom which framed the heavens and the earth.

CHAPTER II.

LEAVES:—FORM AND VENATION.

PLATES III. & IV.

LEAVES form the respiratory and digestive apparatus of the plant. Their position on the stem is such as enables them to expose a large surface to the action of the sun, light, and air; and the numerous pores (*stomates*) with which their surfaces are furnished allow them to exhale gaseous matters freely, as well as to aërate the juices conveyed to them from the stem.

A leaf consists of two parts: a flat, expanded portion called the *blade*, or *lamina* (*l*, FIG. 3); and the *leaf-stalk*, or *petiole* (*p*). The blade of the leaf is its principal portion, and its *margin*, or boundary, defines the shape of the leaf.

Exceptions to this rule occur in cases where the outline of the leaf is very irregular, or deeply cut, such for instance as in the leaf of Thorn-apple (PLATE XV.). In defining the form of such a leaf, it is usual to consider an imaginary line bounding its extreme points, called a *circumscription*. In this sense the leaf is said to have an ovate form.

The *lamina*, or *blade*, has two faces: the upper one, when the leaf is in its natural position, is turned, more or less, towards the sky; the lower towards the earth. The *base* of the leaf is that part of it to which the stalk is attached, when present, or by which the leaf itself is joined to the stem. The *point* of the leaf is opposite to the base. The *blade* of the leaf is traversed by numerous lines, forming, as it were, a framework on which it is stretched; these are most prominent on its under surface, and are called, according to the degree of their prominence, *ribs*, *veins*, and *nervures*. When one vein extends from the base to

the point of the leaf, dividing the blade into two equal, or nearly equal parts, it is called a *midrib* (*m*, Fig. 4).

The *venation* of leaves is a term applied to the branching of the *rib* or *ribs, veins,* and *nervures,* through the blade; and is either,

Parallel-veined—when the veins proceed from the base to the point of the leaf in a *parallel* direction (Fig. 1).

Curvinerved—when the principal veins run in a curved direction from the base to the point of the leaf. *Ex.* Plantain (Plate XXXVI.).

Reticulated, or *net-veined*—when the veins and nervures branch laterally from the rib or ribs, through the blade of the leaf, the primary veins not reaching to the margin (Figs. 3, 4).

Feather-veined—when a prominent midrib, or vein, gives off other (primary) veins laterally, which go directly to the margin of the leaf (Figs. 9, 14).

Radiated—when the principal ribs or veins radiate from a common point of the leaf-stalk, or base of the leaf (Figs. 7, 15).

Terms defining the *forms* of leaves are applied—1. to their *general outlines*; 2. to their *bases*; 3. to their *points*; 4. to their *margins*.

Entire leaves are those whose margins are continuous and uninterrupted (Fig. 2).

Divided leaves have their margins cut into various forms, either regularly or irregularly (Figs. 9, 29). When these divisions extend deeply into the leaf, from the margin inwards, the leaves are termed *lobed* (34, 35).

Compound leaves are those having two, or more, separate *leaflets* (*pinnæ*), with a stalk common to all of them. *Ex.* Potato (Plate XVII.).

1. Simple leaves, whose venation is either *parallel, reticulated, feather-veined,* or *radiated.*

The forms of such leaves *in their general outline* are usually designated either by a real or supposed resemblance to some

geometrical or other figure. Thus there are on Plate III., Fig. (1) *linear*; (2) *lanceolate*; (3) *oblong*; (4) *ovate,* or egg-shaped; (5) *obovate,* with the narrow end to the stalk; (6) *oval,* or *elliptical*; (7) *roundish*; (8) *reniform,* or kidney-shaped; (9) *cordate,* or heart-shaped; (10) *obcordate,* with the narrow end to the stalk; (11) *cordate-acuminate,* or heart-shaped, with a lengthened narrow point; (12) *sagittate,* shaped like an arrow; (13) *hastate,* shaped like a halbert; (14) *spathulate,* shaped like a spatula; (15) *peltate,* shield- or target-shaped; (16) *subulate,* or awl-shaped; (17) *acerose,* needle-shaped; (18) *angular*; (19) *triangular*; (20) *cuneate,* wedge-shaped; (21) *ovate-lanceolate*; (22) *oblique,* or unequal-sided; (23) *truncate,* terminating abruptly; (24) *auriculate,* having a pair of small ears or lobes; (33) *lyrate,* shaped like a lyre.

The forms of *the bases of leaves,* when specially referred to, are designated as *perfoliate,* or perforated by the stem (Fig. 25); (26) *decurrent,* when the blade of the leaf is continued down the stem in a broad or narrow strip; (27) *connate,* when the bases of two leaves are united; (28) *amplexicaul,* or embracing the stem; (11) *cordate*; (21) *ovate*; (5) *attenuated,* or lengthened; (22) *oblique.*

The *points* of leaves are also distinguished as *acute* (Fig. 2); *acuminate,* still more acute; *emarginate,* or notched inwards (6); *mucronate,* when tipped with a sharp spine (20); *obtuse,* rounded at the point (3); *cuspidate,* or tapering to a stiff point gradually (11).

The *margins* of leaves are *entire* (Figs. 1, 2, 3), or *divided* (7, 9).

When the divisions are small and rounded, the leaf has a *crenated* margin (Figs. 7, 9); *dentate,* or toothed (11). When the extremities of the dentations point towards the apex of the leaf, the margin is *serrated* (4, 14); *retroserrate,* when they point to the base. When such divisions are again divided, they

are *doubly-dentate,* or *doubly-serrate* (29), or *irregularly-serrate,* &c.

2. Lobed leaves with *feather-veined* venation are called *pinnatifid* (Fig. 30); *pinnatisect* (31) denotes a still greater division of the margin, extending nearly to the midrib of the leaf; *bipinnatifid* (32), when these divisions are again divided.

A *runcinate* leaf is a form of the *pinnatifid,* in which the divisions of the margin are shaped like the teeth of a large saw. *Exs.* Chicory (Plate XXIII.); Dandelion (Plate XXIV.). The leaf of Thorn-apple (Plate XV.), in which the divisions of the margin alternate in tooth-like projections and rounded curves, is called *sinuated.*

3. Lobed leaves with *radiated* venation are known as *palmifid* or *palmisect* (Fig. 34); the prefix *palmi* denoting the form of venation as radiated, in the manner of the fingers of the human hand. When the divisions extend still further, they are distinguished as *tri-lobed, quinque-lobed* (35), &c.

4. Compound leaves with *feather-veined* venation are called *pinnate,* and are more closely defined by the number of pairs of leaflets (*pinnæ*) of which they are composed. If of one pair only, *unijugate* (Fig. 36); if of many, *multijugate* (37, 38). When each entire leaflet is composed of several small ones (37, *l*), the leaf is *bipinnate* (37). *Tripinnate* is a term applied to *bipinnate* leaves in which the leaflets are again *pinnate.* When the division of the leaf into leaflets extends still further, it is called *decompound* (41). *Equally-pinnate* is a term applied to compound leaves terminating in a pair of leaflets (37); *unequally-pinnate,* if terminating in one (38). When the leaflets alternate with each other (38), the leaf is said to be *alterni-pinnate*; or *interruptedly-pinnate,* when some of the leaflets are much smaller than the others. *Ex.* Potato (Plate XVII.). Compound leaves are also designated as *ternate* (29).

5. Compound leaves with *radiated venation* are known as

palmate, digitate, ternate (Fig. 10), *quinate,* or *septenate* (39); these last terms defining the number of their leaflets as either 3, 5, or 7, joined to the stalk at one point.

Pedate leaves are such as have their lateral leaflets again divided into segments. *Ex.* Hellebore (Plates XXXIV. & XXXV.).

The attachment *of leaves to the stem* is either by a stalk, or (when this is absent) by the midrib, when they are said to be *sessile. Ex.* American Tobacco (Plates I. & XI.).

The position *of leaves on the stem* is either *opposite, alternate,* or in *whorls* or *verticils.*

Opposite *leaves* (Plate IV. Fig. 42) are grouped in pairs at the extreme points of any diameter of the stem.

Alternate *leaves* are placed separately at different heights on the stem (Fig. 40). *Ex.* Tobacco.

Whorled, or *verticillate,* is a term applied to the position of three or more leaves, placed at different points of the stem, in the same plane (Fig. 43).

Variations in the forms of leaves on the same plant are continually occurring, the leaves situated at the base of a stem having for the most part more strongly-developed characters than those found on any other part of it. The reason of this will be readily understood on reflecting that the lowermost leaves are not only of older growth, but that heat, light and air being essential to their existence, their vital activity is exerted in that direction from whence these proceed, and from the effects of which the leaves disposed on the stem above serve to shade them. Barley seeds, grown in earth, and placed in the darkened recess of a chimney-corner, will, on germinating, bend their leaves forward in the direction of the least ray of light. This and many other experiments prove the value of the solar rays to plants; and repeated observation has confirmed their disposition to move towards the sun. Botanists, therefore, when defining the forms

of leaves of many plants, refer to them either as *radical* leaves, *stem* leaves, or *floral* leaves. The Tobacco and Dock plants (Plates I. & XXIX.) furnish examples of the variations here alluded to.

The *texture* of leaves, more especially of their blades, is considerably modified in their outward aspect, both by their venation and the presence or absence of *hairs* or *glands*. A broken surface, by reflecting less light to the eye, assumes a rougher texture and a darker colour; on the other hand, leaves whose outer coverings are of a waxy nature (*e.g.* Laurel), and consequently with more or less polished surfaces, have a brilliant and sparkling appearance.

The presence of *hairs* in any quantity on a leaf, will give, according to *their* nature, the soft downy texture of the under surface of the leaf of Coltsfoot, the roughness of the Potato leaf, or the prickly character of the leaves of Sunflower and Comfrey. The Tobacco leaf, both in its natural and cured conditions, is peculiarly sticky to the touch, owing to the easy fracture of its numerous glandular hairs, which discharge their contents: the immense hydraulic pressure to which the cured leaves are submitted in packing them for exportation, is, similarly, the cause of that peculiar greasy appearance which they assume on the application of moisture previous to their manufacture.

Terms which explain themselves, such as *elastic, brittle, succulent, leathery,* are applied to those conditions of the leaf which depend for their peculiar characters on the form and structure of the venation and blade, the predominance in either part of cellular, fibrous, or vascular tissues, and the character of the epidermis. In their green state, the leaves of Elecampane (Plate XXVI.) furnish examples of strength afforded by fibrous tissue in the midrib and veins. The garden Cabbage leaf has a *succulent* midrib and veins, and the blade partakes of both the *leathery*

and *brittle* characters. When young, the cellular tissue predominates in this leaf, and in others that form our vegetable food; but with age the fibrous tissue becomes more abundant, making them "stringy," and consequently less palatable.

Time produces other changes in the tissues of the leaf, as the plant grows to maturity. Its epidermis thickens, the cells forming its substance gradually harden, and their contents change their colour from green to some shade of yellow, red, or brown; at the same time starch, and matters partaking of a resinous character, are formed, whilst the tissues through which the crude sap found its passage to the leaves become stopped up by organic matters deposited within them, circulation is prevented, their functions cease, and the leaf falls.

CHAPTER III.

VEGETABLE CELLS AND VESSELS, AND THEIR CONTENTS.

PLATE V.

EXCEPTING among the lower forms of vegetation, and the minute parts of the structures of some flowers, the unassisted eye can readily distinguish the forms of the different organs of plants. To obtain a knowledge of their *anatomical structure* requires the use of a microscope, and special treatment of those parts which form the subjects of inquiry. This instrument not only exhibits to us their internal anatomy, but, in many cases, reveals those phenomena of life which form the subject of the Physiologist's researches.

The examination of any portion of a plant, either from the root, stem, leaves, or flowers, shows that it is composed of an aggregation of *cells* and *vessels.*

The Vegetable Cell is described by Vegeto-physiologists as a minute and perfectly closed *sac,* or *vesicle,* formed by a very transparent solid membrane, the *cell-wall* (FIGS. 1 *w,* 7 *w*).

Among things evident to the unassisted sense of sight, a closed and inflated bladder, in which the skin represents the cell-wall, and the enclosed space that of the cell-cavity, has, not inaptly, been chosen as an illustration, on a large scale, of a vegetable cell, as revealed to us by the microscope.

This sac, or vesicle, has certain organizable matters contained within its cavity—the *cell-contents* (FIG. 1, *a, b, c*), on which its life and development depend.

The Cell-wall.—The *permeability* of the *cell-wall* is a necessary

condition of the cell in performing the functions of absorption and transmission of fluids and gases : it would appear that it is only when it becomes charged with secretions partaking more or less of the solid form, that such functions cease to be performed by it.

Endosmose, an action which is induced whenever two liquids of different densities, capable of mixing with each other, are separated only by a membranous partition, is readily admitted of by the cell-wall, which thus exerts an influence on the life of the cell as an individual organism, collecting and distributing its fluid contents, and determining the relation between them and the contents of the cells by which it is surrounded. Endosmose is also brought into play by the different densities of the fluid matters contained in the cells of the roots of plants, and in the soil through which they ramify.

Capillarity*, another physical force, is exerted by certain organs largely developed in most vegetable tissues, the *vessels* and *ligneous cells*, which, in virtue of their form, convey water with nutrient matters in solution (the crude sap), upwards, through the stem to the leaves.

Endosmose and capillarity are, again, excited, if not called into action, during the healthy growth of a plant, by the continued evaporation of moisture from the surfaces of its leaves and stem, through the numerous pores (*stomates*) existing there. To these forces may, perhaps, be added an agency purely chemical, exerted by the mutual reaction of the mineral constituents which are drawn from the soil, and the organic substances within the cell, constituting its entire or partial contents.

The *walls* of cells and vessels, in very many cases, are subject,

* The force to which this term applies is of the nature of a molecular action established between two bodies. It is exhibited in a narrow glass tube containing water : the height of the liquid at the sides near the glass is greater than at the middle of the water-surface, this elevation being due to the exertion of the force of attraction alluded to between these substances.

at an early period of their growth, to the formation of deposits, either homogeneously, or partially only, on their *inner* surfaces, which are thereby thickened and strengthened. Over the *entire* surface this deposit occurs in the form of lamellæ, or plates of different thicknesses, due to the formation of consecutive layers: when only *partial*, it gives rise to the peculiar appearance observed on the walls of cells and vessels, either as *pits*, or depressions of the surface, or as fibres in the form of *rings*, *bars*, or *spiral coils*.

The *outer* walls of the cells forming the epidermis of many plants thicken to a considerable extent. By some physiologists this is supposed to be due to an excretion from their surfaces. Such a thickening is to be observed in the epidermal cells of many tough leaves, such as those of the Aloe, and forms a homogeneous pellicle, known as the *cuticle*. It is also visible overlying the walls of the cells composing the *lymphatic* hairs on the leaf of the Sunflower (PLATE V. FIG. 21, *c*).

Cell-contents.—In young cells, such as those composing the epidermal tissue of the leaf-stalk of Burdock (FIG. 1), careful observation with the microscope enables the observer to detect a very fine granular membrane adhering to the cell-wall, which, on treatment with alcohol, becomes detached from it. This membrane Mohl has designated the *primordial utricle* (1, *a*); and the opaque viscid fluid with granules intermixed (*b*), which it encloses, he calls *protoplasm*. In or near to the centre of the young cell is the *nucleus* (*c*), which appears as a small, round, transparent body; sometimes two such occur in the cavity of the cell.

Named as cell-contents, the foregoing have a special interest for those whose studies comprehend more particularly the phenomena connected with vegetable life (vegetable physiology); they will not, therefore, require to be again alluded to in these pages.

Organic substances are of very frequent occurrence in the

cells of plants. Such are *chlorophyll*-granules (green colouring matter), contained in the *prismatical* (Fig. 2, *a*), *lobed* (2, *c*), *ellipsoidal* (2, *b*), and *irregular* (2, *d*) cells, forming the substance of the leaf of Tobacco. Enclosed, again, within these chlorophyll-granules, *starch-granules* frequently occur; the largest of these, discovered by Mohl, was but the 1-300th, and the smallest 1-2000th of a line in its longest diameter.

Raphides are frequently met with in the cells, or among the intercellular spaces (Fig. 7, *i*) of vegetable tissues. These bodies occur as *acicular* (needle-shaped) crystals in the cells of the bulb of *Polyanthus tuberosa* (3), and in enormous quantity in the roots of *White Hellebore** (sneezing-snuff); they are also found in an agglomerated condition, as crystals of four-sided prisms with rather obtuse points, in the leaf of Rhubarb (Plate XXXI. Fig. 4). The medullary plates of Logwood contain large quantities of crystals, in the form of octahedra with sharply-defined edges and angles, and four-sided prisms acuminated at their ends (Plate X. Fig. 4). Another form of these bodies is found in the sub-epidermal cells (*c*, Fig. 4) of the leaf of *Ficus elastica,* where they are collected on a stalk of cellular tissue projecting into the cavity of the cell, and enclosed by a membrane; they are called *cystolithes.* The chemical composition of these crystals is that of an organic or other acid in union with an earthy base; *e. g. oxalic acid* and *lime,* forming *oxalate of lime*; *phosphoric,* or *tartaric acid,* with *lime* or *magnesia.*

Fixed oils, occurring in a fluid form, are often met with in the cells of plants, and are distinguished under the microscope by their refusal to mix with water, and by their highly refractive power.

Forms of Cells and Vessels. (Plate V.)—A lifetime would

* It is likely that to the presence and peculiar form of these bodies the action of the ground root on the *pituitary membrane* is in a great measure due.

scarcely suffice to observe and to describe the various forms of cells met with in vegetable structures; there is, however, a certain regularity of form, between widely-extended limits, to which the cells and vessels most commonly found may be referred. For the sake of perspicuity, and as answering sufficiently the present purpose, they may be conveniently classed under the two forms, *spherical* and *oblong*.

The original form of the vegetable cell may be said to be that of a *sphere* (Fig. 7); but this shape is considerably modified, both by its position relatively to other cells, and by the peculiar circumstances of its development and the functions it performs, either physically, organically, or both, as part of the tissues of the living plant.

"In examining the form of the cell, we have to take notice that it depends upon two circumstances. On one hand, the form of the cell is determined, like that of every organic body, by its indwelling laws of development; on the other hand, the individual cell, in the far greater majority of cases, cannot follow those laws uninterruptedly, because it forms part of a compound tissue, and is compelled, by its intimate connexion with the surrounding elementary organs, to accommodate itself to the space thus determined for it, and, in consequence of the pressure to which it is exposed laterally from the surrounding elementary organs, to assume forms which would be foreign to it under conditions of free, unrestrained development*."

The influence exerted on the form of the cell by pressure, serving to modify its original spherical tendency, is exhibited in the loosely aggregated cells of a young plant, the tissue of which is lax (Fig. 7), or in the more firmly and closely compacted cells forming the *pith* of the Elder tree (8), which here assume the form of hexagons when viewed in transverse section, or with somewhat square outlines in a vertical position (9) †.

* Von Mohl, "The Vegetable Cell," Henfrey's Translation, p. 2.

† Analogous to this is the shape of the cells of the Wasp's nest, when aggregated together; the cells, when found single, are uniformly circular.

Next to the truly spherical form may be named those cells (FIG. 2) of which the green parts of leaves are ordinarily composed, and whose surfaces are, for the most part, but partially in contact. The substance of the leaf of Tobacco (PLATE XII. FIG. 1) furnishes examples of cells occurring in the forms of *cylinders* (2, *a*), *ellipses* (*b*), or *irregularly-lobed* cells (*c*, *d*).

A form of cell very common in the epidermal tissue of the *leaf-stalk, ribs,* and *veins* of leaves, is seen at FIG. 1. These are more or less elongated, and slightly distended in the direction of their shorter or transverse axes, owing to their lateral development, and to the tension exerted upon them from within by those tissues which they enclose and protect. Cells of a *sinuous* or *flexuous* form, such, for instance, as form the epidermal tissue of the *leaf-blade,* are of very common occurrence (PLATE XII. FIG. 2, *z*). In the epidermis of the upper and lower surfaces of the *blade* of the leaf of Stinking Hellebore (PLATE XXXV. FIG. 2, *z*), they assume a zigzag shape.

As examples of the forms assumed by cells which develope freely, that is to say, out of contact with other cells, or uninfluenced by any mechanical force that these would exert upon them, reference may be made to the cellular appendages found on the outer surfaces of plants, the *hairs* and *glandular* bodies, presently to be noticed.

Passing to the consideration of those forms of cells that are *oblong,* and whose development is in the direction of their longest axes, are those elongated cells (FIG. 10) forming, in part, the cortical integument of the leaf-stalk and midrib of Burdock. These cells have one, occasionally both their extremities pointed.

Elongated cells tapering to a point at both ends (FIG. 12) constitute a large proportion of *wood.* They occur for the most part with their walls considerably thickened, giving them both strength and durability. A peculiar form of such cells occurs in Pine (PLATE IX.) and other *Coniferous* wood (13), having

their sides marked with peculiar depressions (*c*) on their surfaces, which, on the sides of those cells in contact, coincide with each other, and form cup-like cavities between them.

The Vessels which are found in the interior of plants are formed out of *vascular utricles,* placed end to end, the partitions between them being caused by the contact of their end walls, which ultimately become absorbed. The imperfect absorption of the wall of the vessel is at times very evident—*e. g.* the dotted duct (Plate VIII. Fig. 3, *d*).

Secondary Deposits.—Both Cells and Vessels have their walls thickened on their inner surfaces by deposits, which in these organs take very beautiful forms. In the former, as, for example, in those from the stem of the *Cactus,* this deposit takes the form of distinct rings (Fig. 14); in other cases nearly the whole of the cell-wall is covered by it, its absence being noted on those parts which are marked with elongated bars, or dots (15). Similarly, the cells of the pith of Elder (8, 9), and the elongated cells of the wood (12), have their sides marked with minute dots.

Porous cells, in which the cell-wall has become entirely absorbed at those parts where the pores or holes exist, are frequently met with. The leaf of *Sphagnum* (Plate X. Fig. 7) is entirely composed of a single layer of such cells, in which openings (*p,* Fig. 8) occur not only between two contiguous cells, but also on those surfaces of the cell-wall which are exposed to the external air. In their cavities, and lying upon the inner faces of their walls, is a secondary membrane of fibrous structure (*f*) formed into rings, and taking a spiral direction.

In the vessels known as *dotted ducts* or *pitted vessels* (Fig. 16) their walls are marked with innumerable small *dots* or *pits,* which, under the microscope, appear as so many luminous points surrounded by a circular, or more commonly elliptical boundary, which is darker. These *pits* or *dots* are caused by the absence,

at these particular points, of the deposit formed as a secondary membrane on other parts of the wall of the vessel, on its inner surface (Plate VIII. Fig. 3, *d*).

In the true *spiral vessels* (Figs. 18, 19, 20) the secondary deposit takes the form of a spirally-wound fibre lying on the interior of the wall of the vessel, with the intervals between the coils either lying close (18), or at some distance from each other (19).

According to Mohl *, "if the vessel is developed in an organ which has already completed its longitudinal growth, the turns of the spiral fibre lie close together (Fig. 18); but if the organ undergoes elongation after the completion of the development of the vessel, the turns of the fibre are drawn far apart (Fig. 20) by the stretching which the vessel suffers; consequently very loosely-wound spiral vessels are usually found in the posterior first-formed portion of the vascular bundle, nearest to the pith, while those lying nearest the bark have closer convolutions."

The *annular* vessel exhibits this deposit as a fibre taking the form of a ring. Occasionally both a spiral fibre and a ring are found in the same vessel (Fig. 22).

In the *reticulated* vessel the markings on its walls are more irregular in their form than in the preceding. In these the fibre takes a somewhat vertical, as well as a more or less spiral position (Plate VII. Fig. 5, *r*).

A modification of the reticulated vessel occurs in the *scalariform* duct, whose sides are marked transversely, but in a somewhat regular manner (Fig. 17). They occur abundantly in some species of Tree Ferns.

In Beech-wood, vessels are to be met with having their ends marked with *spiral* or *reticulated* fibres, and the remainder of their surfaces with *dots* only (Plate IX. Figs. 1, 2, *d*).

* "The Vegetable Cell."

CHAPTER IV.

ANATOMY OF PLANTS.

PLATES VI.-XII.

THE *roots, stems, leaves,* and *flowers* of plants are formed of *tissues* composed of aggregations of cells and vessels, some of whose forms have been described in the foregoing chapter.

Structure of the Root. (PLATE VI.)—The root is the first-formed organ of a young plant produced from a seed, and the first perceptible indication of seed-growth or germination.

In the interior of every seed capable of producing a plant is lodged the *embryo* or *germen* of a new plant, but often too minute to be seen with the naked eye. In many seeds this is either wholly or partially enclosed in a substance, differing greatly in the quality of its texture, to which the name of *albumen* has been given. The *embryo* and *albumen* (when present) are enclosed in an integument called the *testa,* or seed-coat, on which a scar, the *hilum,* is at times visible.

The *embryo* consists of one or more *cotyledons,* or seed-leaves, a *radicle,* and a *plumule.* In the seeds of plants of endogenous growth there is but one cotyledon; they are, from this circumstance, named *monocotyledonous*; when two or more cotyledons exist (as in the seeds of plants of exogenous growth), they are termed *dicotyledonous.*

A good example of a dicotyledonous seed is found in the Scarlet-bean (FIG. 2), with its testa (*t*), on which the hilum (*h*) is very perceptible. FIG. 3 is a representation of one cotyledon

of the Bean, after germinating for forty-eight hours. At *s* is the scar left on detaching the remaining cotyledon from the germinated embryo; *p*, the plumule, with young leaves at its extremity; and at *r* is the *radicle*, projecting directly from the interior of the seed as a conically-shaped body, forming an *axial root.*

A grain of Barley, germinated for fifty-six hours (of which Fig. 4 is a highly-magnified representation), is an illustration of a seed with one cotyledon (*c*), albumen (*a*), and testa (*t*); the rootlets (*r r*), after bursting the seed-coat, have emerged at one end of the grain. Figs. 5–8 represent the germinated embryo removed from the grain, and viewed on its back and front faces, in which *c* is the cotyledon; *p*, the plumule, or oldest, first-formed leaf; *s*, its sheathing portion slightly extended; and *r r*, the adventitious roots or rootlets. Fig. 7 represents the plumule, *p* (a sheathing leaf), detached from the cotyledon at *a*; and at *p*, Fig. 8, is another (the youngest) leaf enclosed within the older one, *l*, which has been removed.

The root of a plant of exogenous growth is a direct prolongation of the stem downwards, or an *axial* root; the root of an endogenous plant, on the other hand, is never a direct lengthening of the stem, but rather a lateral development of it; such roots are called *adventitious*.

The axial root (*r*, Fig. 3), and the adventitious roots (*r r*, 5), when examined under a simple lens of low power, are seen to consist of a mass of delicate cellular tissue, from the outer surfaces of which proceed numerous extremely minute extensions of it, in the form of *fibrillæ*. Fig. 11 represents a longitudinal section of a small portion of an adventitious root, strongly magnified,—*a a* being the cellular tissue, in which the nascent *ducts* and *vessels* (*b*) are making their appearance as a central vascular bundle. At *p* is the *pileorhiza*, or root-cap, a layer of cellular tissue attached to the apex of the root by per-

sistent cellular tissue, the remaining portions of it being free. When of older growth, the root presents much the same anatomical structure as the stem from which it proceeds; in Exogens, the same division into medullary, wood, and cortical systems. In the *adventitious* roots of Endogens (FIG. 10, *r r*) the separate fibro-vascular bundles of the stem (represented by lines) proceed downwards into the roots. Unlike the stem and leaves, the roots of plants are not furnished with *stomates.*

The root of a plant holds it firmly to the earth in which it grows; and by the permeability to fluid and gaseous matters of its tissues, and that of the delicate suckers thrown out from its surface, it absorbs from the soil water, and the nutrient matters which it contains, proper for the plant's nourishment. The passage of these matters in an upward current to the stem is assisted by the capillarity* of the numerous vessels in the root, and thence onwards by those in the stem and leaves.

Structure of the Stem. (PLATES VI.–X.)—The tissues of the stem are arranged into systems very distinct in their characters; and, according to the plan of their arrangement, botanists have classified flower-bearing plants into groups or divisions, the most important of which are *Exogens* and *Endogens* †. The stems of plants belonging to both these divisions possess a *cellular*, a *fibro-vascular*, and a *cortical system.*

The arrangement of these three systems in the stem of an Exogen is well seen in the herbaceous stem of Tobacco of one year's growth, at PLATE VII. FIG. 1, which represents a small segment magnified 150 diameters, and viewed both horizontally and vertically. At *p* is the central cellular system, a tissue

* See note to page 13.

† As only a general idea of the subject is intended in these pages, it is sufficient to refer to these two great divisions, the former of which includes most of the vegetation of this country, either in trees or shrubs.

composed of somewhat loosely aggregated cells, forming the *pith*; a fibro-vascular system, made up of elongated cells of the fibrous type, and of the vessels known as *dotted, spiral, annular,* and *reticulated.* These, arranged in wedge-shaped masses or bundles (one of which is seen at *w*), form the wood of the stem. The *cortical* system (*b*) is composed of layers of cells placed side by side. At *m s* is a ring of spiral vessels, forming the *medullary sheath* surrounding the pith, *p*; and at *m r*, the *medullary rays,* formed of compressed cellular tissue, running between the fibro-vascular bundles, connecting the central pith with the outer bark or rind, *b*. At *c* is the *cambium* layer, or region of growth; and at *ep* the layers of cells forming the epidermis, to which hairs, *h*, are attached.

A minute portion of the stem of Tobacco, cut transversely, and magnified 200 diameters, is seen at PLATE VIII. FIG. 1, where *l l* represent the ligneous cells, and *d d* the mouths of the vessels, together forming the wood of the stem. At *m r* is a portion of a medullary ray, some of the cells containing starch. At *b* are the cells of the cortical system, with starch and other matters contained in some of them. FIG. 2 represents a portion of FIG. 1, magnified 350 diameters, and exhibits the dots on the walls of the cells of the medullary plates, *m r*, the starch-granules in their interior having been acted upon by iodine. FIG. 3 exhibits this structure viewed in a fragment cut vertically, and across a medullary ray; where *d*, a dotted duct, cut open, is enclosed on either side by *l l*, wood-cells; with the cellular tissue of the periphery of the stem, *b*, containing starch-granules; *m r* is a portion of a medullary ray, seen in the direction of its depth, the starch in its cells being coloured by iodine.

The structure of the entire stem of an Exogen is represented in the diagram, PLATE VII. FIG. 2, in transverse section. The wood, *f v*, is concentrically arranged, in wedge-shaped masses, around a central pith, *p*, from which the medullary plates, *m r*,

radiate to the bark, *c*, which is thus connected with the innermost pith. A view of such a stem in a vertical position is given in the diagram, Fig. 3, in which the innermost dark lines, *m s*, represent the medullary sheath, from which the spiral vessels of the leaf-stalk, *s*, emanate, their fibro-vascular tissue being supplied from the inner face of the woody tissue, *f v*.

The mode of growth of stems formed on the above plan is by the addition of wood to the outside of that previously existing, a manner of increase indicated by the term *exogenous*; the bark increases, at the same time, on its inner surface, the source of addition or growth lying in the *cambium* region. As one such layer is formed during the growth of each season, a ring is formed, which marks the boundary of an old and the beginning of a new deposit. The number of these, therefore, which occur in a stem, when cut across, denote its age.

The structure of a fibro-vascular bundle in the stem of an Endogen (*Phœnix dactylifera*) is seen at Plate VI. Figs. 12, 13, in transverse and vertical sections; in which *p* represents the cellular system of the stem, enclosing numerous bundles composed of, *l*, *ligneous* cells; *v p*, *elongated* cells with thick walls; *d*, *reticulated* ducts; and *s v*, *spiral vessels*. At Fig. 10 is a diagram of an Endogenous stem viewed vertically; each fibro-vascular bundle being represented by a dark line curving outwards in its downward course, to form a fibrous network (*false bark*), and issuing from the stem at its upper extremity, to form the woody tissue of a leaf. The position of these bundles in the stem is represented in transverse section by the diagram, Plate VII. Fig. 6, in which they are seen lying irregularly scattered through its substance.

The special characteristics of this form of stem-growth consist in the absence of any distinct separation of the systems (as in Exogens) into *pith*, *wood*, and *bark*, and the absence of a *medullary sheath* and *medullary rays*. Its mode of growth is by

the formation of wood-bundles in its centre, which gradually force those of older growth outwards,—a peculiarity of increase which the name *Endogen* is intended to indicate.

The stem of a plant serves as a mechanical support for the leaves which grow from it; it also conveys, in an upward current, by the elongated cells and vessels of the wood, the *crude sap*, obtained by the root from the soil. From the wood, the sap is conducted into the upper surfaces of the leaves, where it is elaborated, and then proceeds by their under surfaces to the bark, down the stem, and laterally to its interior, by the medullary plates. The innermost wood in time becomes charged with the secretions so deposited in its tissues by this inward horizontal current, until it is coloured and hardened by them, and rendered incapable of receiving more: in this state it is known as *heart-wood*.

Heart-wood. (Plates IX. & X.)

Beech-wood.—Fig. 1. A section taken in a *vertical* direction: *d*, a dotted spiral vessel lying among the elongated wood-cells. At *m r* are portions of the medullary plates. Fig. 2. A *transverse* section of the wood, showing the mouths of the vessels lying scattered among the wood-cells: *m r*, the medullary plates seen in the direction of their length; *z* is a band or zone showing the termination of an old, and the beginning of a new year's growth. Fig. 3. A section cut *tangentially*, or in a direction at right angles to Fig. 2, exhibiting the vessels, *d*, and wood-cells, *l*; *m r*, the medullary plates, formed of two or three rows of cells, showing their thickness or depth.

Mahogany-wood.—Fig. 1. A *vertical* section of the wood, showing the dotted duct (*d*) cut open in one part, lying among the wood-cells, *l l*. The medullary plates, *m r*, and the cells composing them, are much bolder in their character than those of Beech-wood. Fig. 2. A *transverse* section of the wood:

d, the mouths of the dotted vessels; *l l*, the wood-cells cut across the direction of their length; *m r*, the medullary rays, which are transparent, the cells composing them containing minute spherical bodies, coloured deep red. Fig. 3. A *tangential* section: *m r*, the medullary rays, seen in their depth, in which the colouring matter is also visible; *l*, cells of the wood.

Pine-wood.—Fig. 1. A *vertical* section, showing the elongated cells of the wood,—their sides turned towards the medullary rays, *m r*, being marked with *pits*, having the appearance of discs. Fig. 2. A *transverse* section of the same wood, in which the medullary rays (*m r*) appear as numerous narrow dark bands, the cells forming them being dotted; *z* is a band or zone showing the part to which addition has been made in the growth of one year. Fig. 3. A *tangential* section at right angles to Fig. 2; the wood-cells (*l l*) are not marked with pores on those surfaces which this section exhibits. At *m r* are the medullary rays, composed of a single row of cells.

Logwood.—Fig. 1. A *vertical* section of the wood: *l l*, elongated cells of the wood; *c*, elongated thick-walled cells, their sides marked with extremely minute dots, and containing within their cavities crystals which are slightly coloured; *d*, a dotted duct; *m r*, medullary rays. Fig. 2. A *transverse* section of the wood; the letters refer to the same tissues as in Fig. 1. The elongated cells (*l*) and the thick-walled dotted cells (*c*) are seen in this view to alternate with each other in distinct layers. Fig. 3. A *tangential* section of the wood taken at right angles to Fig. 2,—the medullary plates, *m r*, being seen in the direction of their depth.

Fig. 4. Crystals from Logwood, found in the elongated thick-walled dotted cells (*c*, Fig. 1). Their forms are octahedra with sharply-defined edges and angles (*a*), and four-sided prisms acuminated at their ends (*b*).

FIG. 5. Malt sprouts.—The dried rootlets (malt-dust) of germinated and kiln-dried barley; slightly magnified to show the *root-caps* at their extremities.

FIG. 6. Starch, from Orris-root (*Iris Florentina*).

FIG. 7. A leaf of *Sphagnum acutifolium,* magnified 40 diameters. The entire leaf is composed of a single layer of cells, of the form seen at FIG. 8; their sides and ends touching. Irish peat, which has been frequently used in the adulteration of snuff, contains the leaves and other parts of this plant in great abundance.

FIG. 8. A single cell from the leaf of *Sphagnum acutifolium,* with the *annular* and *spiral* fibre (*f*) in its cavity; *p p,* pores in the cell-wall. Magnified 350 diameters.

Structure of Leaves.—A leaf is either attached to the stem by its midrib, or by means of a stalk, which forms a channel of communication between it and the stem on which it grows.

The structure of the *stalk, midrib, veins,* and *nervures* of the leaf, consists of a mass or masses of fibro-vascular (woody) tissue, arranged either centrally in one bundle, as in Tobacco (PLATE XI. FIG. 1), or in separate and distinct bundles, as in Burdock (PLATE XIX.), surrounded by cellular tissue, and enclosed in an epidermis. The fibro-vascular (woody) tissue is a process of the medullary sheath of the stem in Exogens (*m s,* FIG. 3, PLATE VII.), and the inner portion of its wood (*f v*); consequently the reticulated (*r*) and dotted vessels (*d*) (FIG. 5, PLATE VII.) found in the stem-wood are also present in the midrib and veins of the leaf. The cellular tissues are derived from the bark of the stem. In Endogens the entire woody bundles proceed into the leaves (PLATE VI. FIG. 10, *a*).

A *transverse* section of a leaf-stalk, midrib (PLATE XI. FIGS. 1 & 3), or vein of a leaf, exhibits the general form of its *outline,* as well as the character of its *internal structure.* The

form of the outline of such a section is extremely varied, being *circular, elliptical, lobed,* &c.; whilst that portion of it which represents the upper surface of the part from which it is taken is frequently grooved in an angular manner (Plate XXVIII. Fig. 1), or, on the other hand, forms an elevated ridge (Plate XI. Fig. 1); these depressions or elevations are greater or less, as the section is taken from the base or the point of a leaf-stalk, midrib, or vein.

In the stalks and midribs of many leaves, the tissue at their peripheries forms a well-defined band, bounding them, as in Butterbur (Plate XX.); in others, this tissue occurs in detached masses (Burdock, Dock), which form lobes or ridges on their outer surfaces; and in others, again, it is confined to a small part only of their surfaces, as in the upper portion of the midrib of Rhubarb (Plate XXXI.).

This tissue, forming the *thickened cortical integument,* is easily seen, when present, under a very low magnifying power, in examining a transverse section of a midrib in water, and consists of layers, or rows, of elongated cells (Plate V. Figs. 10, 11), with somewhat regularly-formed intercellular passages between them, these last containing *intercellular substance* in their cavities. It is well seen in the midribs of the leaves of Butterbur, Burdock, Dock, Coltsfoot, &c.; in the Tobacco-leaf it is altogether wanting.

The arrangement of the *woody* and *cellular* tissues, in a transverse section of the midrib of Tobacco, is seen at Plate XI. Figs. 1–4, in which the former is collected in a central mass in a horse-shoe form, repeated again in the leaves of Thorn-apple (Plate XV.) and Deadly Nightshade (Plate XVI.). In Mullein (Plate XXXIII.) this bundle curves upwards and inwards at its outer surfaces. In the midribs of other leaves, their woody tissue, instead of being central, is split up into a number of separate bundles, having various outlines (though

similar in their internal composition), and more or less concentrically arranged. In Coltsfoot (Plate XXII.) these bundles have an elliptical outline; in Comfrey (Pl. XXVIII.) the lowermost bundle takes the form of a boat's stern.

Towards the apex of the midrib, the woody tissue, when central, becomes gradually lessened in its dimensions, though but slightly altered in form; or, when arranged in separate masses, these gradually diminish in number, their disappearance arising from their previous lateral development, to form the ribs, veins, or nervures of the lower part of the leaf, which partake more or less of the structure of the midrib from which they originate.

Both the woody and cellular tissues extend to all parts of the leaf; but in the *blade*, the latter, forming its substance (*spongiform tissue*), takes different characters in the arrangement of its component cells and intercellular spaces. In the upper part of the leaf of Tobacco (Plate XII. Fig. 1), this tissue is made up of a series of cylindrical cells (*a*), somewhat loosely arranged side by side; among them occur numerous intercellular cavities, some of which (as at *b*) lie immediately under the breathing-pores (*stomates*), *s*. To these succeeds another layer of cells (*c*), very irregular in their form and position, and to this again, other two layers (*d, e*). The whole of the cells in this part contain chlorophyll-granules, which impart to the leaf its green colour.

The external covering or *epidermis* of a young stem, and that on the stalk, midrib, veins, and blade of the leaf, which, when detached from the underlying tissues, appears to the naked eye as an extremely delicate and transparent membrane, is composed of cells of various forms, according to the part it covers. In the stem, midrib, and veins of the Tobacco-leaf (Plate XII. Fig. 2, *m*), the cells of the *epidermis* are of a *tabular* form; in the blade of the leaf (*l*) their outlines take a *wavy* or *sinuous* course.

The *structure* of a leaf-vein is seen at Plate VII. Fig. 4, which represents a minute portion of a vein of a Tobacco-leaf laid open; *s v* are the spiral vessels surrounded by *l*, the ligneous cells, enclosed within the epidermis, *ep*. The *position* of a leaf-vein in the cellular substance of the Tobacco-leaf is represented at Plate XII. Fig. 1, where *f v*, a portion of the woody bundle from the midrib, proceeds among the spongiform tissue of the leaf-blade; *p* is a portion of the cellular tissue of the outer portion of the midrib.

It is among the cells forming the *epidermis* of the under sides of most leaves that the peculiar cellular bodies, *stomates*, occur in the greatest abundance; they are also found on the stem, midrib, and veins. These minute bodies (Plate XII. Figs. 1 & 2, *s*) are formed by the junction at their ends of two kidney-shaped cells, which have an aperture left between them, through which the passage of air or gases takes place to or from the external air, which, by means of the large intercellular cavities underlying these bodies, is thus connected with the innermost tissue of the leaf. Their special office is the aëration of the sap, or juices deposited in the leaf, previous to its downward current to the stem and root, and for the emission of moisture or other gaseous matters which they may be said to exhale. According to Henfrey*, the leaf of the Cherry-laurel contains on its lower face 625, and the Lilac 1000 to the square line, or 25,000 and 40,000 to the square inch,—numbers that may help us to form a notion of the rapidity with which the digestive and respiratory processes may be carried on by leaves, as well as the influences that moisture and change of temperature exert through them upon the plant.

Many plants have the epidermis of their stems or leaves (sometimes both) furnished with cellular appendages in the form of *hairs or glands*, which are occasionally visible to the naked eye, or

* "Elementary Course of Botany," p. 521.

evident to the touch. In these minute bodies the microscope reveals to us characters so marked, both of form and general appearance, as to enable us to tell with certainty to what leaf they belong.

Lymphatic hairs are those in which no coloured matter is deposited in any of their cells. These are usually *simple and regular* in the form and arrangement of their cells.

Glandular hairs, on the other hand, have some of their cells (usually the terminal one) coloured by some matter deposited within their cavities. These are *usually more complex and irregular* in the form and arrangement of their cells.

The structure of both descriptions consists of a series of cells joined together. The cell or cells at the *base* of the hair, forming, as it were, its point of attachment to the epidermis, is either a *simple* projection or elongation of a single cell of the latter, and in a direction at, or inclined to, a right angle to it (*ex.* Tobacco), or of a series of cells arranged in a circular manner, forming a *compound* base (*ex.* Sunflower).

Glands are also constructed by the union of cells of various forms and arrangement; they occur in Rhubarb and Dock, as a collection of cells forming minute conical elevations on the epidermis of the leaves, and also project inwards into their substance (PLATES XXX. & XXXI.).

Overlying the epidermis, and firmly attached to it, is occasionally found a transparent homogeneous pellicle, called the *cuticle.* It is well seen under a glass of sufficient power (430 diameters) in the hairs of the leaf of Sunflower (*c*, FIG. 21, PLATE V.). In other leaves (*ex.* Rhubarb, Dock) it may be seen in the form of delicate, wavy, or irregular lines, running for the most part parallel with the outline formed by the cell-walls. It generally requires the use of tests and special treatment to render it distinctly visible.

TOBACCO.

1. *Nicotiana Tabacum,* Linn. 2. *N. rustica,* Linn.
3. *N. persica,* Lindley.

Natural Order, **SOLANACEÆ,** Nightshades, Lindley.

Plates I. II. XI. XII.

1. *N. Tabacum* (American Tobacco). An herbaceous plant, a native of Tropical America. The stem grows to the height of 6 or 7 feet, bearing ovate, oblong-lanceolate, acuminate, sessile leaves, of a pale green colour, sticky to the touch, and covered with glandular hairs. The plant has an extremely pungent, unpleasant odour. Flowers pink, with the segments of the corolla pointed.

2. *N. rustica* (Syrian Tobacco). An herbaceous plant, indigenous in America; grows wild in Europe, Asia and Africa. Stem from 3 to 5 feet in height. Leaves stalked, ovate, obtuse, entire. Flowers green, the corolla with rounded segments.

3. *N. persica* (Tobacco of Shiraz). Native of Persia. Stem-leaves amplexicaul, oblong, acuminate. Flowers white, segments of corolla emarginate and unequal.

Uses.—As a remedial agent, it relaxes muscular fibre. The leaves of American and Syrian Tobacco are used in cases of colic, hernia, constipation, ischuria, dysuria, tetanus, dropsy. In the form of an infusion, as a topical remedy in gouty and rheumatic inflammations, and as an infusion or ointment in porrigo and other skin diseases (Pereira). Shiraz or Persian Tobacco is not used in medicine (Lindley).

The leaves of *N. Tabacum* constitute all the American cigars and Indian cheroots. The Turkish, Syrian, and Latakia Tobaccos are the produce of *N. rustica*. *N. persica* forms the finest Persian Tobacco; but not suited for cigars, from the difficulty of making it burn (Lindley).

Plate XI. Fig. A. A leaf of American Tobacco, drawn to a scale of 1 inch to 2 inches.

Plate XI. Fig. B. A leaf of Syrian Tobacco; scale of 1 inch to 3 inches.

Plate XI. Fig. 1. A diagram representing a transverse section, magnified, of the midrib from the leaf of American Tobacco (A), in which the woody bundle (*fv*) is collected in one mass, in a somewhat horse-shoe form; *c* is the cellular tissue, left blank; *ep*, epidermis. Fig. 2. A similar diagram of the midrib near its apex.

Fig. 3. A portion of the woody bundle from the midrib (as seen in Fig. 1, *f v*), magnified 220 diameters. At *s* are starch-granules, contained in a single cell of the cellular tissue, surrounding the fibro-vascular bundle.

Fig. 4. A diagram representing a transverse section of the midrib of the leaf (B) of Syrian Tobacco, in which the woody bundle is less curved and more elongated than in Fig. 1.

Plate XII. Fig. 1. A section of a leaf of Tobacco, cut in a direction at right angles to the midrib of the leaf, and vertically through its substance; as in manufactured "cut" tobacco: magnified 220 diameters. At *a* are the prismatically formed cells of the upper portion of the leaf, and at *c*, *d*, *e*, layers of lobed and ellipsoidal cells, forming the middle and lower portions of its substance, containing minute granules of green colouring matter (*chlorophyll*). At *ep* are the cells of the epidermis of the upper and lower surfaces of the leaf, and at *b*, intercellular spaces underlying the stomates, *s s*. At *f v* is a woody bundle, forming a portion of a leaf-vein pro-

ceeding through the cellular tissue of the midrib (*p*); *h h* are large glandular hairs attached to the epidermis; *g*, a smaller glandular hair.

Fig. 2. A minute portion from the epidermis on the under surface of the leaf, from the midrib (*m*) and lamina (*l*). *h h*, large glandular hairs (one broken); *g*, a smaller glandular hair; *s s*, stomates; *s''*, an artificial stomate, caused by the falling-off of a glandular hair; *z*, the cells with wavy outlines forming the epidermis of the lamina of the leaf.

The *larger glandular hairs* (*h*) are composed of a series of oblong cells joined end to end; their terminal glands are somewhat oval in form, consisting of an aggregation of minute cells clustered together, in the interior of which, a yellowish granular substance is visible. The bases of these hairs are simple.

The *smaller glandular hairs* (*g*) are club-shaped bodies; the upper portions of them are rounded, and consist of numerous cells, in the cavities of which yellow colouring matter is visible.

Distinctive Characters.—The form, venation, and entire margins of the leaves, and the absence of a leaf-stalk in American Tobacco.

Microscopic.—The form of the woody bundle in the midrib (Plate XI. Figs. 1, 2, 4), and the compact arrangement of its cells and vessels (Fig. 3). The large and small glandular hairs, their bases and points.

Plate XIII.

Tobacco (*pure*).

[The student should make himself well acquainted with the subjects in Plates XV.–XXXVI. before studying this and the following illustration.]

1. Cells of the epidermis of the midrib of leaf, with large glandular hairs attached. 2. Cylindrical, ellipsoidal, and lobed cells, containing *chlorophyll*. 3. Cellular tissue of the midrib. 4. Spiral and dotted vessels from the midrib. 5. Fibrous cells from the midrib or veins. 6. Portion of the woody bundle of the midrib, cut transversely. 7. Epidermis from the leaf-blade, and part of a woody bundle from a leaf-vein, with large glandular hairs, attached and separate. 8. Smaller glandular hairs, separated. 9. Gland from the tip of a hair. 10. Starch-granules.

Magnified 200 diameters.

Tobacco (*adulterated*).

1. *Cellular* tissue. 2. Portion of a leaf of *Elecampane*. 3. Cells from the epidermis of the midrib of leaf of *Dock*. 4. Fragment of a leaf of *Foxglove*. 5. Fragment of a leaf of *Thorn-apple*. 6. *Tobacco* hairs, with a portion of woody bundle from the midrib of the leaf, cut transversely. 7. Cells containing *chlorophyll*-granules. 8. A portion of a woody bundle from the midrib of *Burdock* (broken). 9. Spiral, annular, and reticulated vessels. 10. Stellate hairs from the leaf of *Mullein*. 11. *Lobed* cells from the interior of a leaf. 12. Hairs from *Comfrey*.

Magnified 130 diameters.

THORN-APPLE.

Datura Stramonium, Linn.

Natural Order, **SOLANACEÆ**, Nightshades, Lindley.

Plates XIV. XV.

An annual herbaceous plant, occasionally found growing wild in waste places, flowering in the months of June and July. According to Dr. Pereira, the plant is a native of Greece; Dr. Thomson states it to have been originally a native of America. The stem of the plant is much branched in a forking manner; the leaves ovate, unequally sinuate-dentate, smooth, and of a dull green colour. The whole plant emits a nauseous, fœtid odour. The narcotic and poisonous properties are said to be due to a vegetable alkaloid, *Daturine*; analogous to, if not identical with, a narcotic principle found in other plants of the same natural Order.

Christison* states, that in Germany and France the seeds are frequently made use of for the perpetration of crime. In England the powdered leaves and seeds have been known to be introduced into beer for the purpose of stupefying (hocussing), previous to plundering, a victim.

Uses.—The herb, leaves, and seeds, in neuralgia, rheumatism, enterodynia, mania, and epilepsy. The leaves and herb, prepared in the form of cigars, are sometimes smoked by persons afflicted with spasmodic asthma. "The practice," says Dr. Pe-

* On Poisons, p. 841.

reira, "requires very great caution, as it has proved highly injurious, and in some instances fatal."

PLATE XIV. The plant; scale $1\frac{1}{2}$ inch to 1 foot.

PLATE XV. The leaf; $\frac{3}{4}$ natural size.

PLATE XV. FIG. 1. A diagram representing a magnified view of a transverse section of the midrib near to its base and apex, in which the woody bundle is arranged in one mass centrally, in a horse-shoe shape. *c* is its thickened cortical integument.

FIG. 2. A portion of the cortical integument of the midrib, seen in transverse section, and magnified 220 diameters: *c*, cavities of the cells; *i*, intercellular spaces intervening between them; *h*, a lymphatic hair, its entire surface tuberculated; *g*, a glandular hair.

FIG. 3. A portion of the woody bundle at FIG. 1, magnified 220 diameters: *d*, the mouths of the vessels in this part.

FIG. 4. A fragment of the epidermis of the under side of the midrib, magnified 220 diameters: *h h*, lymphatic hairs; *g*, a glandular hair. The tuberculated surface of this tissue is represented by the fine dots.

The *lymphatic hairs* are composed of a series of oblong cells, which gradually taper to a rounded point at the extremity of each hair. They are occasionally branched, and have simple bases.

The *glandular hairs* have round or elliptically-formed heads, attached to oblong cells forming their stalks.

Distinctive Characters.—The sinuated margin of the stalked leaf.

Microscopic.—A transverse section of the midrib (FIG. 1) is readily distinguished from that of TOBACCO by its thickened cortical integument (2). The arrangement of the cells and vessels of the woody bundle is much less regular and compact than in TOBACCO (3). The lymphatic hairs, though they

resemble those found on the leaf of Potato (Plate XVII.), are readily distinguished from them by the forms of the individual cells, as well as by the bases of the hairs, which are simple, and their points, which are blunt and not recurved. The occasional branching of these hairs is also very peculiar. I have been unable to discover a branched hair on the leaf of the Potato.

DEADLY NIGHTSHADE.

Atropa Belladonna, Linn.

Natural Order, **SOLANACEÆ**, Nightshades, Lindley.

Plate XVI.

A perennial herbaceous plant, a native of both Greece and Italy. The stem grows to a height of 3 feet, bearing leaves mostly in pairs, of unequal size, broadly ovate and entire. The plant bears large lurid, purple, drooping flowers, in the months of June to August. The fruit, consisting of berries of a shining violet-black, resemble cherries : these are highly narcotic and poisonous, but valuable in medicine. The plant is mostly found growing in woods and waste places. Brandes, in 1819, discovered a vegetable alkaloid, *Atropine,* existing in the whole of the plant; it is, however, obtained principally from the roots, and is a most energetic poison.

Uses.—To allay pain and nervous irritation, tic-douloureux, spasmodic stricture, hooping-cough, maladies of the eyes, epilepsy, hysteria, mania, chorea. It has occasionally been found useful for the relief of phthisis; for this purpose the fresh leaves are infused in a strong solution of opium, then dried, and smoked like tobacco. Used also as a prophylactic in scarlatina by some homœopathic practitioners (Pereira).

Plate XVI. A leaf of medium size.

Fig. 1. A magnified view of a transverse section of the midrib of the leaf, near the base and apex. The dark central mass

exhibits the form and position of the woody tissue in these parts.

Fig. 2. A portion of the woody bundle (*f v*) in Fig. 1, magnified 220 diameters.

Fig. 3. A fragment of the epidermis of the midrib, magnified 220 diameters. *h h* and *g g*, glandular hairs; *s*, a stomate. The fine horizontal lines represent a wavy or striated marking on the outer surfaces of the cells of this tissue.

The elongated *glandular* hairs (*h*) are formed of two or three oblong cells, slightly tapering, and joined at their narrow ends, with a terminal cell of an irregularly oval or elliptical form. These terminal cells are occasionally divided at their bases. The short glandular hairs have very large heads, composed of one oval cell, or of several nearly circular cells collected into one mass, and attached to an oblong cell, forming a stalk. Coloured matter is frequently to be observed in their cavities. Both forms of hairs have simple bases.

Distinctive Characters.—The form of the stalked leaf, more especially its base.

Microscopic.—The arrangement of the woody bundle in the midrib is less compact and regular than in that of either Thorn-apple or Tobacco. From the former it is distinguished by the absence of the thickening layer of tissue in the rind of the midrib (Plate XV. Fig. 2), and by the form of the elongated glandular hairs. These, again, are known from the glandular hairs of Tobacco by the form and structure of their terminal glands, which are for the most part unicellular, and free from coloured matter.

POTATO.

Solanum tuberosum, Linn.

Natural Order, **SOLANACEÆ**, Nightshades, Lindley.

Plate XVII.

An herbaceous plant, growing wild in the mountainous regions of Peru and Chili, on the western coast of South America, and brought to England from Virginia by the colonists sent out to that country by Sir Walter Raleigh in 1584. The plant, according to Dr. T. Thomson, was first cultivated in the neighbourhood of London about the year 1605, but not universally throughout the kingdom until many years after that date. The tubers of this plant in a cooked condition are among the most valuable food used by man; the leaves and fruit are narcotic, the latter especially, containing an alkaloid, *Solanine*, an acrid narcotic poison, two grains of which given to a rabbit produced paralysis of the posterior extremities, and death in two hours. Traces of this substance are also found in the healthy tubers (Pereira).

Plate XVII. The leaf, natural size. Form interruptedly pinnate; colour dark green, and downy; the leaflets entire and oblique.

Uses.—The tubers in their cooked condition as food: also as an antidote in cases of poisoning with iodine. The leaves and fruit in extraction, as a narcotic and antispasmodic, to allay cough, spasms, and rheumatic pains, &c. (Pereira).

The starch (Plate XXXVII.) procured from the tubers is

largely used as an adulterating ingredient in West India Arrowroot.

Fig. 1. A diagram representing a transverse section of the midrib of a leaflet from the base and point, magnified.

Fig. 2. A section of a portion of a leaflet, in a direction at right angles to the midrib, and vertically through its substance. A portion of the woody bundle of the midrib is seen at *f v*; *h h*, lymphatic hairs, their surfaces tuberculated; *g*, a glandular hair; *s s*, stomates on the upper and under surfaces of the leaf. Magnified 220 diameters.

Fig. 3. A portion of the epidermis removed from the under side of a leaflet, at the point of junction of the midrib and a vein (*m*) and lamina (*l*); *h h*, lymphatic hairs; *g g*, glandular hairs. Magnified 220 diameters.

The *lymphatic* hairs (*h*) are formed of elongated cylindrical cells, joined end to end, the last or terminal cells having sharp, transparent, recurved points. Their bases are, for the most part, compound, consisting of two or several cells arranged in a circular manner.

The *glandular* hairs consist of a number of minute cells arranged in rows side by side, forming a gland; these are usually coloured, and attached to a single cell forming the stalks of the hairs.

Distinctive Characters.—The form of the entire leaf, the size of the leaflets, and the obliquity of their bases.

Microscopic.—The lymphatic hairs, their form, recurved points, and compound bases, distinguish them in a marked manner from the lymphatic hairs of Thorn-apple. From the glandular hairs of Tobacco they are as readily distinguished by the absence of a terminal gland, as by their sharp, recurved points, compound bases, and tuberculated surfaces,—characters which also separate them from the glandular hairs of Deadly Nightshade.

BURDOCK.

Arctium Lappa major, Lindley.

Natural Order, **ASTERACEÆ**, Composites, Lindley.

Plates XVIII. XIX. XXI.

A biennial plant, growing wild in waste places, old gravel-pits, and on road-sides; flowering in the month of August. The stem rises to a height of 3 or 4 feet. The radical leaves large, cordate, stalked, their margins having slight dentations at long intervals; their upper faces dull green; the lower whitish, owing to a dense covering of fine silky hair. They have been used fraudulently in the adulteration of Tobacco.

Uses.—Roots, leaves, and fruit, as an alterative and resolvent, in gouty, rheumatic, calculous, and venereal complaints,—properties belonging also to the smaller Burdock. Roots used on the Continent as purgatives and diuretics (Lindley).

Plate XVIII. The plant, drawn to a scale of $1\frac{1}{4}$ inch to 1 foot.

Plate XIX. A leaf, drawn to a scale of 1 inch to 5 inches.

Fig. 1. A diagram representing a magnified view of a transverse section of the midrib near the base, with eleven distinct woody bundles, one of which, cut transversely and magnified 220 diameters, is seen at Plate VI. Fig. 9. At *l* are lobes or ridges on the sides and upper and lower surfaces of the midrib.

Fig. 2. A similar section near the point.

Fig. 3. A portion of the lobe (*l*, Fig. 1), in transverse section, magnified 220 diameters. The cells (*c*), to which the lymphatic hairs with long filaments (*h*) are attached, have a quadrangular

outline; these are succeeded by rows of elongated cells with an oval section, and intercellular spaces (*i*) occurring between them. The spaces enclosed by the circles lying within these are the cavities of the cells of the cellular tissue of the midrib, left blank in Fig. 1.

Fig. 4. A fragment of the epidermis removed from the midrib (*m*) and lamina (*l*), with stomates (*s*) and lymphatic hairs ($h\ h''$) attached. Magnified 220 diameters.

The larger *lymphatic* hairs (*h*) are composed of a series of oblong, oval, or elliptical cells joined end to end, and united to the epidermal cells by compound bases formed of several cells concentrically arranged. The upper cells of these hairs, to the last one of which very long slender filaments are attached, contain matter coloured brown by tincture of iodine. The smaller *lymphatic* hairs (h''), which are extremely numerous, are composed of simple filaments of great length attached to a cell of an elongated or ellipsoidal form.

Distinctive Characters.—The base of the leaf of Burdock (Plate XXI.) may be distinguished from that of Butterbur by the very slight dentation of its margin at long intervals, and by this character from the leaf of Rhubarb, whose margin is entire.

Microscopic.—The form of the midrib as seen in transverse section, the lobes occurring at intervals on its outer surfaces, and the size and arrangement of its woody bundles, separate it from Butterbur, Dock, and Rhubarb. The individual cells of the lymphatic filamentous hairs are longer than those of which the hairs of Butterbur are composed, and the terminal cells of these last are free from colouring matter.

BUTTERBUR.

Petasites vulgaris, Desfontaines.

Natural Order, **ASTERACEÆ**, Composites, Lindley.

Plates XVIII. XX. XXI.

A perennial plant, growing wild in wet meadows, swamps, and on road-sides; bearing flowers in the month of April, previous to the leaves making their appearance. The leaves, some of which are as much as 3 feet in their longest dimensions, are roundish-cordate, unequally toothed, downy beneath, with the lobes of their bases nearly or quite touching. Colour bright green, whitish beneath, with long and very strong stalks. The plant has a thick creeping root (underground stem), from which the leaves arise. It grows in great luxuriance on the banks of the Thames, at Putney in Surrey.

Uses.—None.

Plate XVIII. The plant, drawn to a scale of $1\frac{1}{4}$ inch to 1 foot.

Plate XX. A leaf, drawn to a scale of 1 inch to 4 inches.

Fig. 1. A diagram exhibiting a magnified view of a transverse section of the midrib at its base, showing the arrangement of the woody bundles in its interior, and layers of cells (*ep*), forming a thickened cortical integument, continuous on its outer surface.

Fig. 2. A transverse section of the midrib at its point.

Fig. 3. A portion of the cortical integument (Fig. 1, *ep*), magnified 220 diameters: *h h*, lymphatic filamentous hairs attached; *c*, cavities of the cells underlying those of the epi-

dermis; *i*, intercellular spaces; the circular cells are those of the cellular tissue, left blank in Fig. 1.

Fig. 4. A fragment of the epidermis of the midrib (*m*) and lamina (*l*), with numerous lymphatic hairs (*h*), having simple or compound bases, and extremely long very delicate filaments attached to the extremities of their terminal cells; *s*, a stomate. Magnified 220 diameters.

The *lymphatic* filamentous hairs are made up of oblong or nearly circular cells with very thin transparent walls. Their attachment to the epidermal cells is, in the larger hairs, by three or four cells forming a compound base; frequently, however, it is by a single cell only. The cells in each hair for the most part gradually diminish in size upwards, the terminal one having a long delicate filament attached to it.

Distinctive Characters.—The form of the leaf, the bold character of its venation, and the unequal dentation of its margin distinguish it readily from those of Burdock and Rhubarb (Plate XXI.).

Microscopic.—The form of the transverse section of the midrib, the arrangement of the woody tissue within it, and the thickened cortical integument, continuous on its entire outer surface, form marked characters of distinction between it and the leaves above named. Another distinction rests on the gradual elongation of the cells, relatively to their decrease in dimensions, from the bases to the points of the lymphatic hairs. These hairs have, for the most part, broader bases than those of Burdock, whilst their terminal cells are colourless. The form of the stomates is also worthy of observation.

COLTSFOOT.

Tussilago Farfara, Linn.

Natural Order, **ASTERACEÆ**, Composites, Lindley.

Plates XVIII. XXII.

A perennial plant, growing wild in gravel-pits, waste sandy places, and in chalky clay soils; flowering in the months of March and April, before bearing leaves. Leaves angular, roundish-cordate, toothed; their under sides covered with a dense silky down, giving them a whitish appearance. The plant has a thick creeping root, from which the leaves spring directly.

Uses.—The leaves and flowers in decoction,—a popular remedy in pulmonary complaints, chronic coughs especially (Pereira).

Plate XVIII. The plant, drawn to a scale of $1\frac{1}{4}$ inch to 1 foot.

Plate XXII. A small leaf of the plant, natural size.

Fig. 1. A diagram representing a transverse section of the midrib near its base.

Fig. 2. A similar section near the point of the midrib.

Fig. 3. A vertical section through the lamina of the leaf at a right angle to the midrib. Magnified 220 diameters. At *ep* are the cells of the epidermis of the upper and lower faces of the leaf, with (*s*) a stomate divided vertically. *h h* are lymphatic hairs attached to the epidermis of the under surface of the leaf; at *c* are layers of cells, forming the substance of the leaf, and containing granules of chlorophyll; *o o*, intercellular spaces occurring among the cells of the upper side of the leaf; *o''*, a similar space underlying a stomate (*s*) on the lower side.

FIG. 4. A fragment of the epidermis from the under side of the midrib (*m*) and lamina (*l*), magnified 220 diameters: *s*, a stomate; *h*, one of the larger lymphatic hairs; *h″ h″*, smaller lymphatic hairs.

The larger *lymphatic* hairs (*h*) are constructed of three or more elongated cells, gradually lengthening from the bases of the hairs upwards; the terminal cell having a delicate filament of great length attached to it. The smaller *lymphatic* hairs (*h″ h″*) consist usually of a circular or elliptical cell attached to a smaller one, serving as a stalk. Like the larger hairs, their terminal cells have long slender filaments attached to them, and like them have simple bases.

Distinctive Characters.—The angular form of the leaf, the dentation of its margin, and the abrupt lessening or thinning of the midrib and veins near to the middle of the leaf.

Microscopic.—The transverse section of the midrib is distinguished from that of DANDELION, which it most resembles, by the number and position of its woody bundles. The larger lymphatic filamentous hairs are known from those of BURDOCK and BUTTERBUR by their general outlines, and by the oblong form and number of the individual cells of which they are composed.

CHICORY.

Cichorium Intybus, Linn.

Natural Order, **ASTERACEÆ**, Composites, Lindley.

Plate XXIII.

A perennial plant, growing wild in waste places, on gravelly or chalky soils, all over Europe, bearing bright blue flowers in the months of July and August; the stem attaining to the height of 2 or 3 feet, bristly, and alternately branched. Radical leaves runcinate; the upper oblong, amplexicaul; the floral leaves lanceolate, entire, from a broad clasping base. The dried leaves, steeped in tar-oil, have been used as *fillers* for the adulteration of cigars.

Plate XXIII. Fig. A. is a form of the leaf frequently met with, and is intermediate between the runcinate leaf (B) and the entire leaves growing on the upper part of the stem. Scale, one-half the natural size.

Uses.—Cultivated in various parts of England; also in Belgium, Holland, Germany, and France, principally for the root, which, when roasted, is largely used for mixing with coffee, the exciting effect of which it is said to diminish. "Roasted chicory has been in use as a substitute for coffee more than eighty years, and at the present time is extensively employed for adulterating coffee. It is, however, devoid of that fine aromatic flavour for which coffee is so much admired. By some persons it is said to be both wholesome and nutritive; by others it is declared to be neither the one nor the other. The fact is,

that no obvious ill effects are usually observed by the use of chicorized coffee; but there can be no doubt that roasted chicory must, when taken largely, have a tendency to excite diarrhœa. It scarcely deserves to be called nutritive, since, with the exception of sugar, it is almost entirely devoid of nutritive principles." (Pereira.)

Fresh root tonic and aperient: its decoction employed in chronic visceral and cutaneous diseases (Lindley).

Fig. 1. A diagram representing a transverse section, magnified, of the midrib, near the base; its upper surface is concave.

Fig. 2. A similar section from near the point of the midrib.

Fig. 3. A small portion of the epidermis removed from the under surface of the midrib (*m*) and lamina (*l*), with stomates (*s*) and glandular hairs (*h*). Magnified 220 diameters.

The *glandular* hairs are for the most part highly complex in their structure, having compound bases formed of a series of oval or circular cells joined end to end, concentrically arranged. These are succeeded by a series of four or six oblong cells attached to each other by their longest faces, superposed on which is another series of either two or four cells similarly united, and to these succeed single cells, terminating in a conical gland charged with brown colouring matter. This is the commonest form of structure; but in some of these hairs may be observed an alternation of sets of cells with a single one, on which another tier is again superposed; in others, their attachment to the epidermal cells is by the lowermost single cell, attached to which is a series of cylindrically formed cells joined end to end. There may be distinctly traced a tuberculation on the surfaces of these hairs, which becomes more marked in their terminal cells.

Distinctive Characters.—The form of the leaf, though bearing a strong resemblance to that of Dandelion, has its point acuminated.

Microscopic.—The transverse section of the midrib is concave on its upper surface, and thickly set with glandular hairs. In Dandelion the upper surface of the midrib is convex, and almost free from hairs. The form and structure of the glandular hairs are marked characters.

DANDELION (*Dent de Lion*).

Taraxacum Dens Leonis, Desfontaines.

Natural Order, ASTERACEÆ, Composites, Lindley.

Plate XXIV.

A perennial plant, native of Greece, growing wild almost everywhere, some species affecting meadows and pastures, some dry places, and others wet land and bogs. The plant flowers from March to October; leaves all radical and runcinate, with rounded or obtuse points. The active principle of the root is supposed to reside in a substance procured from it, called *Taraxacin,* or *Dandelion-bitter*; it also yields sugar (Pereira).

Uses.—The fresh root in decoction and extraction. In jaundice, chronic inflammation or enlargement of the liver, dropsy dependent on hepatic obstruction, and dyspepsia attended with deficient biliary secretion; affections of the spleen, chronic cutaneous diseases, uterine obstructions, &c. (Pereira).

Plate XXIV. Leaves of medium size.

Fig. 1. A magnified view of a transverse section of the midrib at its base.

Fig. 2. A similar section near to the point of the leaf. In both sections their upper and under surfaces are convex, and near to them the woody bundles are distributed.

Fig. 3. A fragment of the epidermis removed from the midrib (*m*) and lamina (*l*); *h h,* lymphatic hairs; *s,* a stomate. Magnified 220 diameters.

The *lymphatic* hairs arc of very simple structure,—simple fila-

ments, composed of cells oblong in form and of equal or nearly equal size, joined together: the basal cells of these hairs contain colouring matter.

Distinctive Characters.—The leaf of Dandelion is known from that of Chicory by its obtuse point, and by the convexity of its midrib.

Microscopic.—The form of the lymphatic hairs and the simplicity of their structure distinguish them from all others.

SUNFLOWER.

Helianthus annuus, Linn.

Natural Order, **ASTERACEÆ,** Composites, Lindley.

Plate XXV.

An annual plant, cultivated in gardens for the beauty of its flowers. The stem grows to a height of 7 or 8 feet. Leaves cordate, serrated, three-ribbed, their surfaces thickly set with sharp, stiff hairs; colour dull green, somewhat shining.

Uses.—The seeds for feeding birds; oil is also expressed from them.

Plate XXV. A portion of a leaf, one-half of its natural size.

Fig. 1. A transverse section from the midrib just above its point of junction with the two lateral ribs of the leaf.

Fig. 2. The same near its apex: both magnified.

Fig. 3. Cells (*c*) and intercellular spaces (*i*), forming the thickened cortical integument of the midrib and leaf-stalk, seen in transverse section; magnified 220 diameters. *h,* a lymphatic hair; *h''*, a glandular hair attached to the outermost layer of cells.

Fig. 4. The epidermis detached from a minute portion of the under side of the midrib (*m*) and lamina (*l*); magnified 220 diameters. *h,* lympahtic hairs; *h''*, glandular hairs attached to the epidermis; *s,* a stomate.

Fig. 5. The base of a lymphatic hair detached, showing a part of both its exterior and interior surfaces.

The *lymphatic* hairs, and the entire surface of the epidermis

on the under surface of the leaf, are marked with numerous and minute tuberculations. The compound bases of these hairs consist of a series of oval or circular cells concentrically arranged, forming a dome-shaped projection. To these are attached one or two spherical or cylindrical cells, succeeded by two or more oblong cells, the last being curved, and terminating in a sharp point. Occasionally the bases of these hairs are simple.

The *glandular* hairs consist of a single row of minute, nearly circular cells joined together; the cells at their points are coloured brown.

Distinctive Characters.—A three-ribbed leaf with a serrated margin; its surfaces rough, and prickly to the touch.

Microscopic.—The external form of the transverse section of the midrib, and the internal arrangement of its woody bundles. The lymphatic hairs of SUNFLOWER cannot be mistaken for those of COMFREY, if attention be paid to their structure. The lymphatic hairs of the latter are unicellular, with a single row or tier of cells forming their compound bases; in the former these hairs are composed of many cells, and their bases for the most part are highly complex in their structure. The glandular hairs of SUNFLOWER are not found in COMFREY, nor are the hooked lymphatic hairs of COMFREY present in SUNFLOWER.

ELECAMPANE.

Inula Helenium, LINN.

Natural Order, **ASTERACEÆ**, COMPOSITES, Lindley.

PLATE XXVI.

A perennial plant, growing wild in various parts of Europe, mostly in damp meadows; flowering in this country in the months of July and August. The stem rises to a height of 3 or 4 feet. Leaves unequally-serrate, cordate-ovate, acute, clasping; radical leaves stalked, elliptic, oblong. Colour dark green, downy beneath.

Elecampane-camphor, closely allied in its chemical composition to creosote, and *inulin*, an amylaceous substance, organized, according to Raspail, like common starch, are among the products furnished by the root of this plant (Pereira).

Uses.—The root in powder or decoction in pulmonary affections (as catarrh), dyspepsia, exanthemata. It is rarely employed now by the medical practitioner (Pereira).

PLATE XXVI. A stem-leaf, one-half natural size.

FIG. 1. A magnified view of a transverse section of the midrib near its base. At *ep* is the external thickened cortical integument.

FIG. 2. A similar section near its apex. In both the woody bundles are represented dark, the cellular tissue being left blank.

FIG. 3. A portion of the thickened cortical integument of the midrib in transverse section, with (*h*) a lymphatic hair and (*g*) a glandular hair attached. Magnified 220 diameters.

Fig. 4. A fragment of the epidermis of the midrib (*m*) and lamina (*l*) removed from the under surface of the leaf and magnified 220 diameters. *h h*, lymphatic hairs (some broken); *g*, glandular hairs; *g''*, another form of glandular hair.

The *lymphatic* hairs are constructed of oblong cells gradually lengthening from the base to the point of the hair, each cell being more or less constricted at or near the middle, as in the joints of a bamboo-cane. The cell-walls of these hairs are thick, and the terminal cell of each hair is sharply pointed: their bases are for the most part compound.

The *glandular* hairs (*g*) consist of globular capitate cells charged with coloured matter, united to one or more minute circular cells forming their stalks. The glandular hairs (*g''*) are composed of a cluster of minute, nearly circular cells. The attachment of both forms of hair to the cells of the epidermis is usually of a compound nature.

Distinctive Characters.—The form, venation, and serrated margin of the leaf.

Microscopic.—The form of the transverse section of the midrib, its thickened cortical integument, and the arrangement of its woody tissue. The form of the lymphatic hairs, the constriction of the cells composing them, and their sharply-pointed terminal cells. The two forms of glandular hairs.

COMFREY.

Symphytum officinale, LINN.

Natural Order, **BORAGINACEÆ**, BORAGEWORTS, Lindley.

PLATES XXVII. XXVIII.

A perennial plant, very common in damp places, with yellowish-white or purple flowers, which appear in the months of May and June. Height of stem from 1 to 3 feet, winged in upper part. The upper leaves decurrent; stem-leaves stalked, ovate-lanceolate, attenuated below; colour bright green, and covered with stiff prickly hairs.

Uses.—None.

PLATE XXVII. The plant. Scale, 2 inches to one foot.

PLATE XXVIII. The leaf, one-half natural size.

FIG. 1. A magnified view of a transverse section of the midrib near to its base, showing the separate bundles of woody tissue, the lowermost of which is shaped like a boat's stern. At *ep* is the thickened cortical integument.

FIG. 2. A similar section near the apex of the midrib.

FIG. 3. A transverse section of the thickened cortical integument (*ep*, FIG. 1), magnified 220 diameters: *c*, cavities of the cells; *i*, intercellular spaces; *cu*, the cuticle overlying the outer surface of the external layer of cells, and the lymphatic hair, *h*, which is cut through at its base, and the extremity broken off.

FIG. 4. A fragment of the epidermis removed from the under surface of the midrib (*m*) and lamina (*l*): *h*, lymphatic hairs with compound bases; *h''*, lymphatic hairs with hooked points

and simple bases; *g*, small glandular hairs; *s*, a stomate. Magnified 220 diameters.

Fig. 5. *b*, a glandular hair, detached from the epidermis; *d*, the same hair seen from above. Magnified 430 diameters.

The *lymphatic* hairs (*h*) are each of them composed of a single sharp-pointed cell having a very thick wall with tuberculated surfaces; their compound bases are formed of several circular or oval cells, arranged as a conical or dome-shaped elevation.

The *lymphatic* hairs (*h''*) are also unicellular, their extremities sharply pointed and hooked, and their bases simple.

The *glandular* hair (*g*) is composed of a globular cell, usually containing coloured matter, attached to one or two other oblong cells, forming its stalk.

Distinctive Characters.—The form, venation, and rough, prickly surfaces of the leaf.

Microscopic.—The form of the transverse sections of the midrib of the leaf, the arrangement of their woody bundles, and the presence of the thickened cortical integument. The unicellular lymphatic hairs, their sharp points and tuberculated surfaces. The hooked lymphatic hairs, and the tuberculation of the entire surface of the epidermis. The unicellular structure of the bodies of the lymphatic hairs, and the simple arrangement of the cells forming their bases, distinguish them readily from the lymphatic hairs of Sunflower.

DOCK.

Rumex, Linn.

Natural Order, **POLYGONACEÆ**, Buckwheats, Lindley.

Plates XXIX. XXX.

A perennial plant, growing wild on road-sides, in marshy places, woods and ditches, dry waste places, fields and pastures. Stem from 1 to 5 feet in height, bearing flowers from June to August; leaves oblong or ovate-lanceolate, stalked, cordate, rounded or attenuated at the base, with acute or obtuse points. They have been used in the fraudulent adulteration of tobacco.

Uses.—None.

Plate XXIX. The plant (*R. crispus*). Leaves wavy, curled, acute. Drawn to a scale of 1½ inch to 1 foot.

Plate XXX. A leaf of *R. obtusifolius* with an adherent stipule at the base of the leaf-stalk. Drawn to a scale of 1 inch to 3 inches.

Fig. 1. A magnified view of a transverse section of the midrib of the leaf near its base. At *l* are lobes of thickened cortical integument found at intervals on the outer surfaces of the midrib.

Fig. 2. A transverse section from near the point of the midrib.

Fig. 3. A fragment of the epidermis removed from the under surface of the midrib (*m*) and lamina (*l*). Magnified 220 diameters. *h h*, lymphatic hairs; *g g*, glands; *s*, a stomate.

The *lymphatic hairs* are unicellular with rounded extremities, and their outer surfaces, as well as that of the epidermis, coarsely striated.

The *glands* are circular bodies, composed of several cells concentrically arranged among those of the epidermis, from which they project.

Distinctive Characters.—The form and venation of the stalked leaf, with its adherent stipule.

Microscopic.—The transverse sections from the midrib, with the lobes on their outer surfaces, and their numerous separate bundles of woody tissue, as seen in Fig. 1. The lymphatic unicellular hairs are more elongated and have narrower bases than those of Rhubarb, and the striation on their surfaces is much coarser and more defined; the glands are smaller than those of Rhubarb, and less regular in their form.

RHUBARB.

Rheum hybridum, Murray.

Natural Order, **POLYGONACEÆ**, Buckwheats, Lindley.

Plates XXI. XXVII. XXXI.

An annual, herbaceous plant, not indigenous in this country, but originally imported from China by way of Russia. Pereira states, that of the thirteen species grown in this country, the roots of which he examined, those of *Rheum palmatum* only resembled the true Asiatic Rhubarb imported for medicinal purposes. *Rheum Rhaponticum*, another species, the same author states, is our common or *Rhapontic Rhubarb*, cultivated in this country for the leaf-stalks, which are used for tarts and puddings. The same species is also grown largely at Banbury in Oxfordshire for the sake of the roots, which, when dried, constitute English, or Banbury Rhubarb. *R. hybridum* is cultivated as culinary Rhubarb. The leaves have been frequently used in the fraudulent adulteration of tobacco.

Uses.—The root, in diarrhœa and dyspepsia; as an external application in healing indolent ulcers.

Plate XXVII. The plant, drawn to a scale of 1 inch to 1 foot.

Plate XXXI. A leaf of *R. hybridum*, drawn to a scale of 1 inch to 6 inches: form roundish-cordate; colour dark green.

Fig. 1. A magnified view of a transverse section of the midrib of the leaf near to its base. Fig. 2. The same near its point.

At *c*, Fig. 1, is the thickened cortical integument on the

upper surface of the midrib. The woody bundles lying scattered in the cellular mass of the midrib (which is left blank) are comparatively small and very numerous.

Fig. 3. A portion of the epidermis removed from the under surface of the leaf, and magnified 220 diameters. *h*, lymphatic hairs; *g*, glands; *s*, a stomate.

Fig. 4. A mass of conglomerate *raphides* from the sub-epidermal tissue of the leaf, magnified 430 diameters.

Fig. 5. A gland detached, and viewed in a vertical position.

Fig. 6. The same gland viewed from below.

Fig. 7 represents a vertical section of Fig. 5,—*c* being the general surface of the epidermis of the leaf, from which the glands project slightly.

The *lymphatic hairs* are unicellular, with broad bases, obtuse points, and the exterior surfaces of their cell-walls marked delicately with very fine irregular lines (striated).

The *glands* are minute bodies formed of an aggregation of cells, arranged circularly. They are not level with the surface of the epidermis, but form dome-shaped projections outwards, their lower portions lying imbedded in the substance of the leaf. They usually contain a brownish colouring matter, most easily detected in their cavities when the gland is viewed *in situ*.

Characteristic Distinctions.—The entire margin of the leaf distinguishes it at once from the leaves of Burdock and Butterbur (Plate XXI.).

Microscopic.—The form of the transverse sections of the midrib, the distribution of their woody bundles, and the absence (excepting on their upper surfaces) of a thickened cortical integument, are characters in which they differ widely from the leaves of Dock, Burdock, or Butterbur. The unicellular hairs, the delicate striations on their outer surfaces and on that of the epidermis. The glands are large and numerous; the *raphides* abundant.

FOXGLOVE.

Digitalis purpurea, Linn.

Natural Order, **SCROPHULARIACEÆ**, Linariads, Lindley.

Plate XXXII.

An indigenous perennial plant, growing on hedge-banks and in woods. The stem grows 3 or 4 feet high, bearing alternate leaves, form ovate-lanceolate, crenate, downy beneath; the lower leaves attenuated into footstalks. The plant flowers from June to August. The leaves have been used in the adulteration of tobacco.

Uses.—As a medicinal agent, the effects of Foxglove approximate more closely to those of Tobacco than of any other cerebro-spinant. These two agents agree in their power of enfeebling the action of the heart and arteries. In large doses it destroys life. The leaves, in infusion, tincture, and extract, are used in fever, inflammation, dropsy, hæmorrhages, diseases of the heart and great vessels, phthisis, insanity, epilepsy, and with occasional benefit in scrofula and asthma (Pereira).

Plate XXXII. A leaf, one-third natural size.

Fig. 1. A diagram representing a transverse section of the midrib near its base. The woody tissue is collected in one mass of a curved form. Its position is nearly central; and it is surrounded by the cellular tissue (left blank), the whole enclosed by a thickened cortical integument, *ep*.

Fig. 2. is a similar section of the midrib near its point.

Fig. 3. The cells forming the integument of the midrib

(Fig. 1, *ep*), seen in transverse section, magnified 220 diameters; *h*, a lymphatic hair attached.

Fig. 4. Cells of the cellular tissue of the midrib, seen in transverse section, magnified 350 diameters. *r*, conglomerate *raphides*; *s*, starch-granules.

Fig. 5. A fragment of the epidermis removed from the under surface of the leaf, magnified 220 diameters. At *m* are the cells forming the tissue of the epidermis of the midrib; at *l*, those of the lamina; *h*, lymphatic hairs; $h'' h''$, glandular hairs; *g*, smaller glandular hairs; *s*, a stomate.

The *lymphatic* hairs are composed of a series of oblong cells joined together, gradually lessening from the bases of the hairs upwards, until they finally become pointed at their extremities. Their bases are either simple or compound.

The *glandular* hairs (h'') consist of two or three oblong tapering cells, terminated by one of a nearly spherical form.

The smaller *glandular* hairs (*g*), which are extremely minute and numerous, have spherical cells in which coloured matter is visible, forming their glands; these are attached to one or two oblong cells which form their stalks.

Distinctive Characters.—The form, venation, and divided margin of the leaf, and the woolly texture of its under surface.

Microscopic.—The form of the outline of the transverse section (Fig. 1), with its upper surface grooved, sufficiently distinguishes it from Tobacco and Mullein. The form of the pointed lymphatic hairs, and the number of the cells composing them. The glandular hairs (h'') have their glands formed of single cells. This form of hair is less frequently met with than either the lymphatic hairs (*h*) or the characteristic glandular hairs (*g*), which are very numerous.

MULLEIN—HIGH TAPER.

Verbascum Thapsus, Linn.

Natural Order, **SCROPHULARIACEÆ**, Linariads, Lindley.

Plates XVIII. XXXIII.

An indigenous biennial plant, growing on road-sides and in waste ground, with a stem from 4 to 5 feet in height, flowering in July and August. The leaves ovate-oblong, crenate, densely woolly on both sides, decurrent from one to the other.

Seeds and flowers poisonous; foliage acrid and bitterish (Lindley).

Uses.—Leaves in the form of a decoction in catarrhs and diarrhœa. Fomentations and cataplasms, made of Great Mullein, have been used as applications to hæmorrhoidal tumours and indurated glands (Pereira).

Plate XVIII. The plant, drawn to a scale of $1\frac{1}{4}$ inch to 1 foot.

Plate XXXIII. The leaf, one-half natural size.

Fig. 1. A magnified view of a transverse section from near the base of the midrib.

Fig. 2. A similar section near its point.

In both diagrams the woody tissue is represented dark, the cellular tissue being left blank. At *ep* is the thickened cortical integument on the outer and upper surfaces of the midrib.

Fig. 3. A small portion of the epidermis removed from the under surface of the midrib (*m*) and lamina (*l*). Magnified

220 diameters. At *h h* are the branched or stellate lymphatic hairs. *s*, a broken stomate.

Fig. 4. The upper portion of a broken lymphatic hair, in which the branching takes place at three different points of its stalk. Magnified 350 diameters.

The *lymphatic* hairs are composed of one or more oblong cells joined together, forming the stalks of the hairs. To the upper one of these are attached others of a curved form, with fine sharp points, which radiate from one or more points of its surface. The cell-walls of these hairs are thick; their bases are simple.

Distinctive Characters.—The form, bold venation, and divided margin of the leaf, and its velvety texture.

Microscopic.—The form of the transverse sections of the midrib, the arrangement of their central masses of woody tissue with curved extremities, and the presence of the thickened cortical integument. From Foxglove this section is distinguished by the very slight depression of its upper surface. The lymphatic stellate hairs, which are also stalked, form a very characteristic distinction.

GREEN HELLEBORE.—STINKING HELLEBORE.

Helleborus viridis, Linn. *Helleborus fœtidus*, Linn.

Natural Order, **RANUNCULACEÆ**, Crowfoots, Lindley.

Plates XXXIV. XXXV.

Green Hellebore is an annual plant, growing wild in England and Ireland, in thickets on a calcareous soil; the stem attaining to the height of a foot, with greenish-yellow flowers appearing in March and April. The root of this plant is sometimes substituted for that of the Black Hellebore, which is imported into this country from Hamburg and Marseilles.

Stinking Hellebore, a plant growing wild in England and Scotland, in woods and thickets in chalky districts. Stem 2 feet high, bearing flowers which are greenish, tipped with purple, appearing in March and April. Both plants have pedate, stalked leaves; the leaflets lanceolate, and partially serrated.

Uses.—The leaves are emetic, purgative, and poisonous. Those of *H. fœtidus* have been employed as a vermifuge against the large round worm (*Ascaris lumbricoides*) (Pereira).

Plate XXXIV. A leaf of Green Hellebore, two-thirds natural size.

Fig. 1. A transverse section, magnified, of the midrib of a leaflet near its base.

Fig. 2. A small portion of the lamina of a leaflet cut through its substance vertically, and at right angles to the midrib. At *c*

is the cuticle overlying the epidermal cells of the upper surface, *e*. At *m* are the cells forming the substance of the leaflet; *e''*, the cells of the epidermis of the under surface; *s*, a stomate divided vertically; *i*, an intercellular space beneath it; *h*, a lymphatic hair attached to the epidermal cells. Magnified 220 diameters.

Fig. 3. A fragment of the epidermal tissue from the under surface of a leaflet; from a vein (*m*) and lamina (*l*); *h*, a lymphatic hair; *s*, a stomate. At *f v* is part of a woody bundle of the leaf-vein. Magnified 220 diameters.

The *lymphatic* hairs are unicellular and pointed; their cell-walls very flexible and marked with minute tuberculations. On the cells of the epidermis, more especially those of the laminar portion, a peculiar striation is distinctly visible, an appearance due probably to the wrinkling of its cuticle.

Distinctive Characters.—The pedate form of leaf and the partially serrated margins of its leaflets.

Microscopic.—The form of the lymphatic hairs, their simple bases, tuberculated surfaces, and their flexibility are characters by which the hairs may be readily distinguished from those of Comfrey, to which they bear the nearest, though a very slight, resemblance.

Plate XXXV. A leaf of Stinking Hellebore two-thirds of its natural size.

Fig. 1. A transverse section of a midrib of a leaflet, magnified.

Fig. 2. A minute portion of the epidermis of the upper surface of a leaflet, showing the peculiar wavy outlines of the cell-walls (*z*) of the cells of which this tissue is composed, and the markings on their outer surfaces. At *h* is a lymphatic hair. Magnified 220 diameters.

Fig. 3. A view of a fragment of the epidermis of the under side of the leaf; from the lamina (*l*) and midrib (*m*); *s*, a stomate; *h h*, lymphatic hairs. Magnified 220 diameters.

The *lymphatic* hairs are unicellular, club-shaped bodies.

Distinctive Characters.—The leaves of GREEN HELLEBORE are brighter in colour than those of STINKING HELLEBORE; they differ also slightly in the character of the serration at the margins of the leaflets.

Microscopic.—The form of the unicellular hairs distinguishes them at once from those of GREEN HELLEBORE and the other examples. The peculiar form and structure of the stomates are worthy of observation.

PLANTAIN.

Plantago, Linn.

Natural Order, **PLANTAGINACEÆ**, Ribworts, Lindley.

Plates XXIX. XXXVI.

A perennial plant, growing in fields and waste places, on banks and in pastures; flowering from June to August: the leaves and flower-stalks spring from an underground stem. Leaves broadly ovate, on longish, channeled stalks, venation curvinerved. They have been used in the adulteration of tobacco.

Uses.—The plant is used in some districts for feeding sheep, when grown with a crop of clover. The ripe fruit is collected by poor people, by whom it is vended as food for caged birds.

Plate XXIX. The plant, with its fruit-stalk and fruit; drawn to a scale of 1 to 6 inches.

Plate XXXVI. A leaf; drawn one-half its natural size.

Fig. 1. A diagram representing a transverse section of the midrib near the base.

Fig. 2. The same near its apex.

Fig. 3. A small portion of the epidermis removed from the under surface of the midrib (*m*) and lamina (*l*); with *h*, lymphatic hairs; *g*, glandular hairs; and *s*, a stomate. Magnified 220 diameters. The epidermis is striated and slightly tuberculated.

The *lymphatic* hairs are composed of oblong cells, those at the extremity being sharply pointed, and those towards the base approaching nearly to the circular form; the cell forming the

simple base of each hair is circular and dome-shaped. These hairs have tuberculated surfaces.

The *glandular* hairs have their glands composed of a pair of oval or kidney-shaped cells, slightly coloured, with a single oblong cell for a stalk.

Distinctive Characters.—The form of the stalked leaf and its curvinerved venation.

Microscopic.—The form of the transverse sections of the midrib. The lymphatic hairs are readily distinguished from those of the POTATO by their bases, which are much broader, and by their terminal cells, which are not recurved. The individual cells of the hairs in this example gradually lengthen from their bases upwards: in POTATO, the cells composing the hairs stand in a reverse order—they gradually shorten. The lymphatic hairs of PLANTAIN are known from those of SUNFLOWER and COMFREY by their simple bases; from the latter they are also distinguished by the multicellular structure of the body of each hair.

CHAPTER V.

STARCHES.

Plates XXXVII. XXXVIII.

"Starch," says Schleiden*, "is the most generally distributed substance in the Vegetable Kingdom. I am not acquainted with any plant which does not, at some season of the year, at least at the period when vegetation is inactive, contain more or less starch, frequently only in individual granules in the cells, and frequently entirely filling them in grains of the most different size. The starch-granules adhere quite adventitiously, by means of mucus, to the cell-walls. The umbilicus (hilum), by which the starch-granules are said to be attached to the wall of the cell, is an error on the part of Turpin. The largest granules do not appear to exceed 0·05 of a line in the longest diameter. The starch is most readily obtained by bursting the cellular tissue, and by washing it from the plant; occasionally, however, it cannot be thus obtained, as, for instance, when it occurs combined with much mucus, as in *Hedychium*. The starch in *Maranta arundinacea* (Arrowroot) appears to be the purest. We certainly do not say too much when we assert that starch constitutes the most important, and the almost exclusive food of two-thirds of all mankind. It is certainly contained in all plants, but not always in such a manner as to be sufficient and suitable for nutriment; and sometimes, too, indivisible from other unpalatable admixtures, as, for instance, in the *Horse-chestnut*. Certain parts of plants contain it in the largest quantity, namely

* Principles of Scientific Botany, p. 18; translated from the German by Ed. Lankester, M.D. 1849.

the albumen of seeds (the *Cerealia*), the cotyledons of the embryo (*Leguminosæ*), the medulla or pith of the stem (*Cycadeæ* and *Palmæ* *), bulbs (*Liliaceæ* †), the tubers, root-stocks, and roots of very different families ‡. It occurs in smaller quantities in the bark and the albumen of trees in winter, whence the inhabitants of the Polar regions are able to bake the bark of trees as bread."

Starch, as it occurs in commerce in the form of Arrowroot, Potato-starch, &c., is a white, somewhat gritty powder, having a glistening appearance. When examined under a microscope this powder is seen to consist of a mass of granules, more or less adherent, but easily separable by gently rubbing them with the tip of the finger on a clean glass slide under water. The forms of the granules vary with the plant from which the starch has been procured, being either circular, elliptical, triangular, or irregular figures. In some species of *Euphorbia* they are dumbbell-shaped, or in the form of two spheres united by a long arm; whilst in other specimens they appear as two or more *nuclei* enclosed in a common envelope.

The surfaces of some granules exhibit a peculiar *laminated* or streaky appearance, formed by a series of very delicately marked lines, radiating, as it were, from a common centre—a dark spot (the *hilum* or *nucleus*). In other granules the *hilum* occurs as a long cleft, fold, or slit on their surfaces, or as a series of very delicate fissures radiating from a central spot or cavity.

Of the exact nature of the starch-granule, little beyond its chemical composition is known with any degree of certainty. Schleiden §, who selected the starch of the Potato for his expe-

* As sago, from *Cycas revoluta, Sagus Rumphii, farinifera*, &c.

† *Lilium camtchaticum*, in Greenland, &c., is a source of food.

‡ Potatoes, from *Solanum tuberosum*; Cassava, from *Jatropha Manihot*; Taroo, from *Arum esculentum* (Colocasia macrorhiza?), &c.

§ Principles of Scientific Botany, p. 12.

riments, the granules of which present the *laminated* appearance on their surfaces, concludes that these indicate the surfaces of contact of many hollow, ovate scales, laid around each other, and that these layers, of which the granule is formed, are more aqueous and gelatinous as they lie nearer to the interior. By some the starch-granule is thought to be a vesicle, on which the lines (*laminations*) indicate the *rugæ* or folds into which it is thrown in the contracted state, and that this vesicle occasionally contains a grumous material—amorphous starch. Such is the view taken of its structure by Mr. George Busk. An opinion, still more recent, is that of Dr. Allman, who believes that the granule "is formed out of a series of independent lamellæ, in the form of hollow shells, included one within another." *

Iodine †, according to the degree of its concentration, when dissolved in iodide of potassium, colours starch-granules a pale or dark indigo-blue tint, approaching to blackness: *dilute sulphuric acid* causes them to swell considerably when added to the water in which they are placed. With *polarized light* many starch-granules exhibit a beautifully marked dark cross on their surfaces, the point where these dark bands meet and cross each other being at the hilum of the granule. These are characteristic tests by which the presence of starch may with certainty be confirmed.

"Although," says Dr. Carpenter ‡, "the dimensions of the starch-grains produced by any one species of plant are by no means constant, yet there is a certain average for each, from which none of them depart very widely; and by reference to this average, the starch-grains of different plants that yield this product in abundance may be microscopically distinguished from one another." The difficulty (if not impossibility) lies in discovering this *certain average*: the student, therefore, cannot

* Quarterly Journal of Microscopic Science, Nos. 3 and 7.

† Reagent, No. 4, p. 100.

‡ The Microscope, p. 421.

do better than study the forms of individual granules in each specimen of starch which he examines, paying particular attention to their outlines as the grains move in the *medium* in which they are viewed, and their behaviour with the *reagents* named in another place†.

The following are descriptions of specimens of Starch from different plants, viewed in water. They are illustrated, from my own observation, on Plates XXXVII. and XXXVIII. In order to enable the student to form an idea of *relative magnitude*, the granules in each specimen are magnified 430 diameters, and all drawn to one scale. The measurements given are those made by Mr. George Jackson, as quoted by Pereira.

Tous-les-mois.—Procured, in the form of a white glistening powder, from the tubers of *Canna edulis*, a native of the West Indies, and imported from St. Kitts. The granules of this starch are the largest known; their form is ovate, oval, or oblong, flattened on one surface, with a projection at one or both sides. The *hilum* is circular, and placed at one end, usually at the narrow extremity of the granule. The lines or *laminations* of the surface are numerous, tolerably regular and close.

As measured in parts of an English inch :—

Particles.	Length.	Breadth.
1.	0·0042	0·0035
2.	0·0037	0·0026
3*.	0·0031	0·0027
4*.	0·0032	0·0020
5*.	0·0025	0·0017
6.	0·0013	0·0010

The most prevalent-sized particles are those marked thus, *.

The following characters, which distinguish this starch from that of the Potato, are given by Pereira ‡. My own observations confirm them.

† Page 100.

‡ Materia Medica and Therapeutics, vol. ii. p. 1115, pt. 1. 1850.

"Potato-starch is the only amylaceous substance which can be confounded with *Tous-les-mois*. The two starches may be distinguished by a careful attention to their relative sizes and shapes, to the appearance of their rings (*laminations*), the position of the *hilum*, and the action of polarized light on them.

"First, the particles of Potato-starch are, on the average, smaller than those of *Tous-les-mois*, and are subject to greater irregularity of size (both as regards different sorts of potatoes and the different particles of the same potato).

"Secondly, the larger particles of Potato-starch are more irregular in shape than those of *Tous-les-mois*; the latter are more constantly rounded, or oblong, or ovate-oblong; the former are oval, often approximating in shape to an oyster-shell, a mussel-shell, or a triangle with rounded corners, and being frequently gibbous or tumid at different parts of their surface.

"Thirdly, the rings (*laminations*) seen on particles of *Tous-les-mois* are fine, regular, uniform, concentric, and crowded; those of Potato-starch are coarser, irregular, often excentric, irregularly drawn out, distorted, or more and unequally distant from each other. In Potato-starch a great number of complete rings is visible, and we can trace the lines around the *hilum*, even in the case of many of the larger rings; but in *Tous-les-mois* this can be done with a very few of the smaller rings only.

"Fourthly, in both the *hilum* is situated nearer to the end of the particle; but in Potato-starch this character is less obvious, the *hilum* being frequently less distant from the centre of the particle than in the case of *Tous-les-mois*.

"Lastly, when viewed by polarized light, the cross is less frequently regular in Potato-starch than in *Tous-les-mois*; in the former the arms are often distorted."

Potato Starch.—Procured from the potato by rasping it into water, from which it is deposited as a sediment. It occurs in commerce as a white glistening powder, more or less adherent

in lumps, grating between the teeth. Composed of large and small granules; the larger ones being elliptical or ovate, having the *laminations* strongly marked. The commonest form is that of a triangle rounded at the angles, or of an oyster- or a mussel-shell. The *hilum* is mostly circular, as the particle is viewed from its upper surface (that on which the *laminations* are most evident), or sometimes elongated, when viewed on the under surface (that on which a fold or tuck is indicated). *Laminations* somewhat irregular and strongly marked; nearly the whole of them traceable around the *hilum*, to which they are more or less excentric. The *laminations* occur most strongly marked on those particles which are somewhat flattened; those which are more rounded in their contour are less marked with them on one surface, whilst the opposite surface has the folded appearance.

The smaller particles are more spherical, and their *laminations* less distinct.

As measured by Mr. George Jackson, in parts of an English inch:—

Particles.	Length.	Breadth.
1.	0·0023	0·0016
2.	0·0021	0·0014
3.	0·0018	0·0013
4.	0·0011	0·0009
5.	0·0009	0·0007
6.	0·0007	0·0006
7.	0·0005	0·0005
8.	0·0004	0·0004
9.	0·0003	0·0003
10.	0·0002	0·0002

Rye Starch.—Procured from the raw grain, of which it forms a large proportion.

The form of the largest granules is usually that of a circular, flattened disc, with an apparently depressed centre, having

cracks or fissures on its outer edge. The smaller granules are, or approach to, the spheroidal form. On one of their faces most of the large granules exhibit a folded appearance; viewed edgeways their form is elliptical. The *hilum* is central in position, and its form circular or stellate; that is, with lines radiating from a central point, and reaching almost to the margin of the particle. Circular *laminations* may occasionally be traced, forming rings around the central *hilum*. Mr. George Jackson's measurements of eight granules, in parts of an English inch, are as follow:—

1.	0·0016	5.	0·0005
2.	0·0015	6.	0·0003
3.	0·0013	7.	0·0002
4.	0·0010	8.	0·0001

Wheat Starch.—As procured fresh from the grain in the form of a fine white powder (flour); the granules under the microscope are less variable in their size than those of other specimens. The largest particles are mostly of a roundish, or but slightly elongated form, with one face compressed or flattened; the smallest granules approach more nearly to the form of spheres. The *hilum* is situated at or near the centre, being usually of an elongated form, and more commonly running in the direction of the shortest diameter of the particle: around it, the *laminations*, in the form of very delicately marked, concentric rings, may occasionally be traced. Less frequently, the *hilum* is of a circular form. Mr. George Jackson's measurements give, in parts of an English inch:—

Common Wheat.		Spelt Wheat.	
1.	·0009	1.	·0012
2.	·0006	2.	·0010
3.	·0004	3.	·0005
4.	·0003	4.	·0003
5.	·0002	5.	·0001
6.	·0001		

Barley Starch.—As procured in a fresh state from the grain, in the form of a white meal, and examined under the microscope, the particles are so like those of Wheat-starch in their form and other characters, as to be hardly distinguishable from them. The granules are more varied in their dimensions than those of Wheat; the largest of them are irregularly circular, elliptical, or obscurely triangular; the smallest, nearly spheroidal. Like the particles of Wheat-starch, they are lenticular, their lower surfaces having the folded appearance; on their upper surfaces, the *laminations* are scarcely perceptible. Slight fissures or cracks occur occasionally on their margins, an appearance that I have not observed on the granules of Wheat-starch, from which they also differ in having the *hilum* less centrally placed, and less strongly marked, on the larger granules. On nearly all the smaller particles of Barley-starch the *hilum* may be observed, which is not the case in Wheat. Pereira states that the largest grains are larger than those of Wheat, an assertion which my own observations do not confirm; I have invariably found them somewhat smaller.

The following measurements of seven (including the largest and smallest) grains were made by Mr. George Jackson:—

1.	0·0011	of an English inch.	
2.	0·0010	,,	,,
3.	0·0009	,,	,,
4.	0·0008	,,	,,
5.	0·0005	,,	,,
6.	0·0002	,,	,,
7.	0·0001	,,	,,

Oat Starch.—The contents of the grain afford a white meal with abundance of starch, consisting of small particles, for the most part adhering together at one or more of their faces. The largest granules, when free from contact with others, are more or less rounded in form, and, like most other grains, are lenticular,

or flattened at one side. The *hilum* is evident on the larger granules only, and on these no *laminations* can be traced. Polarized light has no effect upon them which is distinctly visible.

Measured by Mr. George Jackson, six (including large and small) grains gave the following results:—

1.	·0010 of an English inch.		
2.	·0006	"	"
3.	·0004	"	"
4.	·0003	"	"
5.	·0002	"	"
6.	·0001	"	"

Tobacco Starch.—Obtained from the midrib of the leaf, the stem and root in their fresh state (see also Plates XI. & XIII.). Granules extremely small, and lenticular or compressed, the largest roundish-ovate in form, occasionally slightly angular or flattened at some point of their outlines; the smaller granules are nearly spherical. The *hilum* may occasionally be observed, more especially on the smaller granules, but no *laminations* are visible. The granules of medium size are about as large as those of the Oat, and the smallest, as those of Rice.

Rice Starch.—Obtained from the seed freed from its husk. The granules of this starch, as seen under the microscope, are extremely minute, angular, and more or less adhering together, presenting straight outlines on all sides; frequently pentagonal or polygonal in form, with an extremely minute, often imperceptible, central *hilum*. "They are the smallest granules of all the commercial starches" (Pereira).

As measured in parts of an English inch by Mr. George Jackson :—

Particles.	
1.	·00027
2.	·00021
3.	·00020
4.	·00017
5.	·00010
	5)·00095
	·00019=$\frac{1}{5263}$ average diameter.

Bean Starch.—Procured from the cellular tissue (PLATE VI. FIG. 1) of the cotyledons of the Garden-bean (*Phaseolus multiflorus*). Elongated, kidney-shaped, and irregularly-formed granules, exhibiting on one of their surfaces a long slit (the *hilum*) or open fissure, surrounded by folds or plaits; on the other, flattened surfaces, delicate lines or markings, more or less regular in their form. The smallest granules approach nearly to an irregular-oval or spherical form.

Pea Starch.—Procured from the cotyledons of the Garden-pea (*Pisum sativum*). Oblong, kidney-shaped, irregularly-formed granules, the largest of them having an elongated *hilum*, or, more commonly, one of their surfaces strongly marked with plaits or folds surrounding an elongated fissure or cavity. The *hilum* appears to be placed sometimes at one end of the granule, on its flattened surface, an appearance that seems to be due to the gathering up at that point of the folds or plaits visible on the opposite side of the granule. The smallest granules approach the spherical form.

Orris-root Starch. (PLATE X. FIG. 6.)—Procured from the

dry and powdered root (*Iris florentina*). The form of the granules is for the most part elliptical, with a rounded projection at the narrow extremity, near to which is the *hilum*. Other granules are heart-shaped, as if formed of two granules included within one envelope. Delicate *laminations* are visible on some of the larger granules. The smaller granules are nearly spherical or kidney-shaped. According to Schleiden, the granules are "perfectly hollow, apparently cup-like."

Mr. George Jackson's measurements give, in parts of an English inch—

Particles.	Length.	Breadth.
1.	0·0011	0·0010
2.	0·0012	0·0006
3*.	0·0009	0·0006
4.	0·0006	0·0004
5.	0·0004	0·0004
6.	0·0003	0·0002
7.	0·0002	0·0002

* The most prevalent-sized particle.

CHAPTER VI.

THE MICROSCOPE.

Plate XXXIX.

It does not enter into the design of these pages to give a detailed description of the various forms and applications of the instrument to scientific purposes, all that is intended being merely an explanation of the principles on which it is constructed, and its adaptation to the examination of vegetable tissues *.

Construction.—Microscopes, as they consist of a single lens, or of a combination of lenses, are known as *simple* or *compound.* A *lens* is a transparent body, to one or both of whose surfaces a curved form is given, and according to the nature of these curves the various forms of lenses take their names. Sections of the principal forms of lenses in use are given in Plate XXXIX. Figs. 2–7, *a* being the *axis* common to all of them. A lens having its two surfaces unequally curved is known as a *crossed* lens (2). A *plano-concave* lens has one surface flat and the other rounded to a segment of a sphere, the centre of which would be on the side opposite to its plane surface (3). A *double-concave* lens has both its surfaces curved inwards; it is consequently thinner at the middle than at the circumference (4). A *plano-convex* lens has one side flat and the other curved outwards, in

* Those who are desirous of detailed information on the subject may consult with advantage Dr. Carpenter's work, "The Microscope and its Revelations," or Mr. Quekett's book on the same subject.

some segment of a sphere, the centre of which lies on the side of its plane surface (5). A *double-convex* lens has both surfaces curved outwards (6); it is therefore thickest at the middle. A *concavo-convex* lens, with its convex surface of greater radius than its concave surface, is called a *meniscus* (7).

Lenses of every description derive their value from the property possessed by certain transparent media (such as glass, water, &c.) of bending a ray of light in its passage through them, when issuing from a *rarer* or a *denser* medium than the substance of which they are composed. To this property the term *refraction* is applied.

If a ray of light from the air, *a* (Fig. 1), enter the surface of water, or glass, *h h*, in the direction $a\ a''$, or at any other angle with *h h* less than a right angle, it will be bent or refracted *towards* a perpendicular, *e f*, to the refracting surface, *h h*. Instead of passing from *a* to a'' in a straight course, it will pass to *b*. A ray of light (*e f*) falling perpendicularly or at right angles to the surface of the refracting medium, *h h*, will suffer no refraction. It is also found that the *sine* of the angle of incidence, *a c*, and that of the angle of refraction, *b d*, bear a constant ratio to one another in different substances. If the medium be water, the sine of the angle of refraction, *b d*, will be $\frac{3}{4}$ of the sine of the angle of incidence, *a c*; if of glass, the sine of the angle of refraction to that of incidence as 2 to 3; if of diamond, as 2 to 5. It will be observed, therefore, that the *refractive power* of these three different materials increases from water to the diamond.

Light passing *from* a dense medium to one that is rarer, will be refracted in a direction *from* the perpendicular; if from *b* (Fig. 1), it will, on emerging from the denser medium, be refracted in the direction of *a*.

From what has been said, there will be no difficulty in understanding the action of a *plano-convex* lens of glass (*l l*, Fig. 13),

r f being the axis of the lens, and *r r r r*, parallel rays of light falling on its curved surface. These rays will, on entering the lens, be refracted towards a perpendicular to the surface on which they fall; consequently they will be refracted in the direction *l f*, and on emerging from the plane surface of the lens, will be collected together at a point, *f*, called the *focus* of the lens. Supposing rays of light to diverge from *f*, they will be rendered parallel after passing through the lens, *l l*.

The *double-convex* lens of glass, *l l'* (Fig. 16), possesses a still greater refractive power, owing to the curvature of both its surfaces.

Concave lenses, owing to the different direction given to their curvatures, bend the rays of light in a directly opposite manner. *Parallel* rays, *r r r r* (Fig. 14), falling on the plane surface of a *plano-concave* lens, *l l*, will be refracted in the direction *r b*, *r b*; *diverging* rays will be made to diverge still more. *Converging* rays, *b l*, *b l*, falling on the concave surface of such a lens, will, on emerging from its plane surface, pass in a parallel direction to *l r*, *l r*.

Such is the effect produced by these forms of lenses on rays of light, when these are parallel, or issuing from a single luminous point. The surface of every body capable of reflecting light may be supposed to be made up of a number of such illuminating points. If, however, these points be situated above the axis of the lens, the focus will be below it, on the other side; and if below the lens, the focus will be above it.

Let *o* (Fig. 16) represent an object placed in the focus of a *double-convex* lens, *l l*; rays of light proceeding from its extreme points will be above and below the axis of the lens, *a b*, and will, on emerging from the lens, be refracted in the direction *l o''*, forming an enlarged and inverted image of the object *o'' o''* on a surface placed there to receive it.

The *focal length* of a lens is the distance of that point from its

centre at which all rays emerging from its surface are collected together. The focal lengths of lenses made of glass vary with the curvatures of one or of both their surfaces. For a *plano-convex* lens parallel rays will be brought to a focus at the distance of the diameter of a circle, an arc of which its curvature describes; for a *double-convex* lens whose curvatures are equal, at the distance of the radius of either curvature. For converging rays the focal distance will be less, and for diverging rays, greater.

A Simple Microscope is nothing more than a plano-convex, or a double-convex lens, or both combined, mounted in a form (the stand) adapted to the particular purpose for which it is required to be used. To understand its use and value, it should be remembered that the eye judges of the size of an object by the magnitude of the angle under which it is seen; and that it sees minute objects imperfectly is due to the limitation of its visual angle, which does not admit of a sufficient number of rays from the object to enter the eye so as to produce a perfect image of it on the retina.

That the size of an object is due to the magnitude of the angle under which it is viewed is illustrated in Fig. 19, where an object *b* may be supposed to be placed at the most convenient distance for distinct vision, which is different for different eyes, but usually taken at 10 inches. It is evident that by removing the object to a point at half the distance from the eye, to *a*, the object *a* will subtend an angle twice as large as the former; but only a part of it will be distinctly seen,—that part represented lying between the dark lines. If, however, a plano-convex, or a double-convex lens be interposed between the eye and the object *a*, these extreme rays will be refracted by it, and will enter the eye with those refracted from the other points of the object, and the lens will thus have the effect of enlarging the visual angle.

To illustrate the action of a Simple Microscope, let *o* (Fig. 16) be an object imperfectly seen at the nearest limit of distinct vision for the eye at *a*. By interposing the double-convex lens *l l*, the rays from the object entering the lens are refracted in the direction $o'' o''$, and a magnified and inverted image of it, $o'' o''$, is formed on the retina of the eye, at *a*. The eye, therefore, virtually receives an impression of the object, *o*, of the apparent magnitude of $o'' o''$.

A Compound Microscope consists of a combination of lenses: an *object-glass*, which forms a magnified image of an object placed a little beyond its focus; and an *eye-glass*, which again enlarges the image so formed.

To illustrate the action of a Compound Microscope, let *o* (Fig. 20) be the object to be viewed, placed a little beyond the focus of the object-glass, a *double-convex* lens, *l l*, whose focal length is very short. This will form an inverted and highly magnified image of the object in the air, within the tube of the microscope, at o''. At *e e* is the eye-glass, a plano-convex lens, so placed as to receive the rays from the image o'', causing them to converge to the eye, and appearing to come from an object of the apparent size of *a b*.

To simplify the subject, the object-glass and eye-glass have both been considered as single lenses, which, for all purposes of practical utility, would be useless, for the following reasons:—

It is found that rays of light passing through a glass lens, a plano-convex lens for instance (as at Fig. 15, *c d*), do not, on emerging, all meet at the same point; but that rays *a c*, *a d*, passing through the peripheral portion of the lens, are brought to a focus sooner, as at *f*, than those, *b b*, passing nearer to its axis, as at *g*. An indistinct image of an object would therefore be formed both at *f* and *g*, as part only of the rays from the object would be collected at either point. The distance *f g* is called the *spherical aberration* of the lens *c d*; and *s* (the point

where the central and peripheral rays cross each other), the circle of least spherical aberration, where the most distinct image that such a lens could produce would be formed. The way in which this inconvenience is remedied is by combining two lenses whose curvatures, and consequently their spherical aberrations, are in opposite directions. In this way the spherical aberration of a concave lens is made to compensate that of a convex one.

Another defect of simple lenses, which considerably diminishes their utility, is that of forming images of objects with a coloured fringe or border to them, and is called their *chromatic aberration* or *dispersion.* White light, instead of being homogeneous in its composition, as might be supposed, is made up of seven different colours. If a beam of solar light, *a* (Fig. 11), be admitted through a hole in the window-shutter of a darkened room, and allowed to fall on a glass prism, *b*, it will be decomposed, or separated into its component colours, which will be visible on a screen placed to receive them. These colours form a lengthened band, the bottom of which is *red*, then *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet.* The band is called the *prismatic spectrum*, the red rays of which are the least, and the violet rays the most refrangible. Now, every double-convex lens may be considered to be formed of two prisms placed base to base (Fig. 8), and, light passing through it, will have its violet rays, *v v*, brought to a focus at a point nearer to the lens than the red rays, *r r* ; consequently an image formed at *a b* will have a red fringe at its outer margin, and one formed at *c d*, a violet border,—the other prismatic colours appearing between them. The circle of least dispersion occurs at the point of intersection of the violet and red rays. A double-concave lens (Fig. 9) may be regarded as formed of two prisms, with their apices touching, and will similarly affect the image it forms.

The way in which correction for chromatic aberration is

effected, is by taking advantage of the difference that exists between the *refractive* and *dispersive* powers of transparent bodies. The diamond, for instance, has a high refracting power and a low dispersive power; whilst glass has, compared to it, a low refracting power and a high dispersive power. Again, the refractive and dispersive powers of *flint-* and *crown*-glass stand in the same relation to each other,—properties which enable these materials to be made use of, each to neutralize the defects of the other.

The *Achromatic Object-glass,* which is adapted for producing a distinct image of an object perfectly free from colour, is a combination of *three pairs* of lenses, *each pair* consisting of a plano-concave lens of *flint*-glass and a double-convex lens of *crown*-glass (Fig. 10); each combination having its plane side turned towards the convex surface of the one next to it, and so adjusted as to correct the dispersion of the other two.

The *eye-piece,* which in the best Compound Microscopes is substituted for the simple eye-glass, is constructed of two plano-convex lenses, one placed before the image formed by the object-glass, the other behind it. The former of these is called the *field-glass,* the latter the *eye-glass.* The field-glass is so placed as to cause the diverging rays from the object-glass to converge, so that a greater number of them are brought within the sphere of action of the eye-glass, and a brighter and more distinct image is thus produced.

Illumination of Objects.—For opaque objects the commonest form of illumination is by means of *refracting* light upon them with a plano-convex lens (a *condenser*), which is suitably mounted on a frame, and so adjusted that an object placed on the stage of the microscope may receive the rays of light which it concentrates upon it.

Another method of illumination is by *reflection*; and for this purpose many forms of reflectors are in use. The *side-reflector*

of Mr. Ross is a polished concave speculum, so mounted as to be capable of receiving either parallel rays of light from the sky, or the diverging rays from a lamp, and reflecting them on the object on the stage of the microscope.

For viewing objects capable of *transmitting* light through them, a mirror with a plane and a concave surface is fitted to every microscope. Such mirrors depend for their action upon the law, *that when light is reflected from a perfectly polished surface, the angle of reflection is equal to the angle of incidence, in the same plane with it, and on the opposite side of the perpendicular to the reflecting surface.* A ray of light, *a* (Fig. 12), falling on a surface capable of reflecting it, will be reflected to *b*, and would be perceived by an eye placed at that point.

A little consideration of this simple law will make it evident that *parallel* rays of light falling on the *plane* side of a mirror will be reflected *parallel*,—that *parallel* rays falling on its *concave* surface will be made to *converge* to a point on the same side of it as that from which they emanate (the focus of such a mirror), —that *diverging* rays falling on such a surface will, on reflection, *converge*,—and that *converging* rays will be reflected in a condition still *more converging*.

Let *m m* (Fig. 17) be a section of a mirror with a *plane* and a *concave* surface: parallel rays, *g, a, g,* falling on the former, will be reflected back in the same direction, and the ray *g s* falling obliquely on it will be reflected to *s g*. From its *concave* surface, *parallel* rays, *a m, a m,* will be reflected to *m f, m f*,—*converging* rays, *b d,* to *c e,* and *diverging* rays, *f m,* to *m a.*

It is evident that any *transparent* object, placed so as to receive the reflected rays of light from either face of the mirror, will be illuminated by them. This is effected by placing the object on a glass slide on the stage of the microscope, in which an aperture is made so as to receive the light reflected from the mirror, which is placed beneath it, the mirror being so adjusted as to

direct the reflected rays through the object and object-glass into the tube of the microscope. By giving the mirror a vertical and horizontal motion, which is effected by means of appropriate joints on which it moves, light may be obtained from any particular point in the sky, such as a white cloud; or from a lamp placed in front of the instrument. The special use of the plane surface of the reflecting mirror is to illuminate the object at its margin, when the central rays are stopped out. The curved surface is adapted for receiving parallel or diverging rays from any luminous point (a white cloud or a lamp), and reflecting them in a converging or parallel condition on the object, whilst the peripheral rays are stopped out by means of a diaphragm placed under the stage of the instrument.

Management.—Little by way of instruction in the use of the Microscope can be conveyed in writing, the value of the instrument in scientific research depending more upon the student's acquisition of the *art of seeing*, and of *reasoning* upon what he sees, than upon the observance of any rules that could be given, however plain and intelligible. In proportion to his acquirements in this respect, combined with an earnest but patient will, and a mind eager in pursuit of information, there is scarcely any limit to the valuable information that the Microscope may be made to yield.

As to the selection of a Microscope, all that need be said here is, that the form of the *stand* on which it is mounted, though of itself an important consideration, should always be secondary to the choice of the best object-glasses; for it is by these that the real work of the instrument is to be performed. The names of our best English makers (Ross, Smith and Beck, Powell, &c.) are a sufficient guarantee for the excellence of their respective productions, which at the present day are in request in all parts of the world where there are microscopists to use them; and it should be borne in mind that discoveries of the greatest scien-

tific value have been made with "objectives" not in any way to be compared with the works of these makers, in all the essentials of good instruments *.

In the Compound Microscope, the eye-piece, as it magnifies the image of an object produced by the object-glass, will also render any imperfection in that image still more evident, thus increasing, instead of diminishing, the difficulty of viewing it properly. It is therefore of the first importance that the object-glass should be free from any defects, and more particularly that it should be properly *corrected* for both spherical and chromatic aberration. As a general rule, good *defining* power is always to be preferred to *magnifying* power; for it is obviously of more importance to see little, and to see that little distinctly made out in all its parts, than to have an ill-defined image of an object presented to the eye, from which nothing of its real structure can be learned. It may be safely asserted, that the test of a good working instrument, no less than of a good observer, lies in the amount of information that object-glasses of low power may be made to yield: the high powers are more likely to mislead than to instruct those unpractised in microscopy, from the fact of their magnifying those accidental impurities attaching to the object under examination, with the appearances of which beginners are not familiar.

Among *impurities* continually presenting themselves to the observer, are those contained in the water in which the specimen is mounted; or they may consist of such matters as threads from the cloth (either cotton or silk) used in cleaning the glass slide on which the object is placed; or of hairs, dirt of any

* "It should be recollected that Ehrenberg, with a thirty-shilling microscope, produced his great work on the *Infusoria*, a work with which British microscopy has nothing to compare, although it has spent thousands of pounds annually on its instruments."—*Note* by Dr. Lankester in his translation of Schleiden's Principles of Scientific Botany.

description, or even of the epithelial cells from the mucous membrane of the mouth, if a brush passed between the lips has been used to add to or diminish the quantity of water on the slide. From this enumeration it will be seen that *cleanliness* is of the first importance.

Another fruitful source of error in observation is found in the constant formation of *air-bubbles* in the liquid in which the object is placed, between the glass slide and its cover. These air-bubbles have the appearance of bright luminous spots of various shapes and dimensions, surrounded with a dark ring. Their peculiar appearance is due, internally and externally, to the different modifications of the light, which is either transmitted in their lighter portions, or refracted in the darker.

To illustrate this, let x (FIG. 18) be a ray of light, reflected from the mirror of the microscope, passing through the centre of the air-bubble, $p\,h\,g$; let z be other rays passing near its periphery, and $c\,d\,e\,f$ a glass slide on the stage of the instrument, containing water. The rays z, impinging obliquely on the tangential plane of g are in consequence of passing from a denser medium (water) to a rarer medium (air), refracted *from* the perpendicular $g\,v$ to $g\,h$. At h these rays are again refracted, but now, *towards* the perpendicular $v\,h$; consequently, in the direction $h\,i$. On reaching the point i they are again refracted *from* the perpendicular, so that they never reach the object-glass $a\,b$, nor, consequently, the eye. The central rays, x, and those nearly central, y, pass through the perpendicular axis of the air-bubble unaffected; therefore the margin of the air-bubble, as it transmits no rays, will appear dark, and its centre, as it transmits them, will be illuminated.

To these unavoidable obstructions to the successful use of the microscope, to which the best observer is liable, must be added such false appearances as are due to want of dexterity in obtaining specimens of tissues fit for examination, or in badly or carelessly

mounting them. Any or all of these defects are seriously augmented by the use of object-glasses of high power, owing to the amount of detail which they exhibit; serving to perplex those who cannot make due allowance for them.

As there is considerable bodily fatigue attending a long sitting at the microscope (and short sittings are of no use for the purpose of *study*), the student will do well to consult his ease and power of endurance as much as possible. For the attainment of this object, his preference should always be given to that form of stand which has a joint for varying its position, so that an inclination may be given to it in the direction of the eye-piece towards the eye, thus enabling the head and body of the observer to be held in an erect position. Another convenience in this form of stand is, that when so inclined, the stage of the instrument intercepts most, if not all, *incident* light from an object which is required to be viewed by *transmitted* light; consequently the rays of light reflected from the mirror will be less interfered with, and the illumination they afford more intense. In viewing opaque objects, the position of the instrument should be such as to allow the greatest number of incident rays of light to fall on them; and when these come from the sky, the stage of the microscope should be horizontal, and the stand perpendicular.

When object-glasses of higher power than the $\frac{1}{2}$-inch are used, the specimen to be examined should invariably be covered with a bit of thin glass, for the purpose—first, of procuring a perfectly flat surface; secondly, to exclude air-bubbles (when the object is viewed in a liquid); thirdly, to protect the object-glass and its mounting against the injury that some of the liquid *tests* * would be sure to cause, if allowed to touch them.

Examination of Vegetable Tissues, &c. (PLATE XL.)—The most satisfactory method that can be adopted in examining the

* See page 100.

tissues of leaves is, to commence by viewing their surfaces as opaque objects, under a simple lens of low power; and for this purpose portions of them should be mounted on a white ground (a piece of cardboard for instance), and placed on the stage of the instrument: or a similar effect of background illumination may be obtained by the reflecting mirror, by adjusting it so as to throw a field of light around the margin of the object placed on a slip of glass on the stage. This treatment will afford information as to the general character of its outer surfaces, and the presence or absence of hairs; it will also discover whether the leaf has been subject to the attacks of insects, or the deposit of their eggs among its tissues, or any decomposition that may have commenced in their structures. Parts so affected must be avoided, either for studying their structure, or for the purpose of analysis.

The simple dissecting Microscope* is an instrument admirably adapted for such an examination, and possesses other advantages that cannot be too much dwelt upon. When the arm carrying the lens admits of movement in every direction—backwards, forwards, laterally and vertically, and the stage is large and firm, it allows the whole surface of an object to be readily examined, and admits of the use of one or both of the observer's hands to tear or cut any particular part of the tissue most favourable for further examination. Portions of such tissues, almost invisible to the naked eye, such as a hair or a few cells, may also by its aid be dissected out, and transferred to a slip of glass for examination under the Compound Microscope. By pursuing this method, much unnecessary loss of time and

* Several forms of this instrument are in use, many of them being extremely portable. I have seen none that unite the desirable qualifications of steadiness and durability so completely as that made by Mr. Ross. This instrument possesses other advantages in the size and strength of the stage, which render it well adapted for the purpose of *dissection.*

patience will be saved, which are too often wasted in guessing at the position of an object with the unassisted sight.

For obtaining transverse sections of the *midribs* or *veins* of leaves, a small piece (Fig. 4) should be selected, from a fresh leaf; or if from one that has been dried, it must be steeped in warm water. A good sound cork is then chosen, which fits exactly into either end of a glass tube (1) about four inches long. The cork being divided into two equal parts (2, 3), one of these pieces (2) is taken, and a groove is cut in it sufficiently deep to receive the projecting midrib, which is placed in it. The flat faces of the pieces of cork are now brought together, and their narrow ends inserted and gently pressed into the mouth of the glass tube for about half an inch. The upper end of the cork and the knife (12) are then dipped into clean water, and thin slices of the cork are made in a direction perfectly horizontal and towards the operator. The whole arrangement, and the position of the hands are seen at Fig. 11. With a little practice, slices of any degree of thinness and transparency may be thus obtained; they should then be floated from the knife into a saucer containing water, and the cork separated from them by means of a camel's-hair pencil (5); they are then transferred on slips of glass for examination, as uncovered objects, under the dissecting microscope.

The examination of several such sections will yield full information—1. of the form of the outline; 2. the arrangement of the woody tissue, whether massed in one, or separated into several bundles; 3. the character of its cellular tissue, and whether the cells, or intercellular spaces composing it, contain starch, raphides, or other deposited matter; 4. the presence or absence of a thickened cortical integument; 5. the character of the epidermis, and the attachment of hairs to its surface, and whether these are lymphatic or glandular.

An inch, or half-inch simple lens, used with the mirror for a

background illumination of such sections, will give ample information as to these characters. If it be required to examine any of them more in detail, the entire section may be placed under the Compound Microscope; or any part of it may be either carefully cut out, on the stage of the dissecting Microscope, with the knife (Fig. 13), or torn away with a pair of needle-points * (6, 7, 8), from the surrounding tissues, care being taken not to injure the particular part required for examination. Individual cells with their contents, single hairs, and other such minute objects, may be prepared in this way for examination under the Compound Microscope, taking care not to injure the object in transferring it to a clean glass slide.

Vertical sections through the substance of the blade of the leaf are made in the same manner as the transverse sections of the midrib; but in this case it is better to select a bold, strong vein for placing in the groove of the cork (Fig. 2). The advantage of this plan is, that the section of the vein to which the portion of the lamina is attached (and which always has a tendency to turn over) is preserved in an upright position for viewing. Sections of this part require to be cut excessively thin, owing to the obstruction to the passage of light through the tissue, which the green chlorophyll-granules, contained in

* These simple and most useful instruments any one can make for himself. The handles are nothing more than those used for camel's-hair brushes. Into the end of these the pointed end of a needle is inserted, to the distance of half an inch, or more. It is then withdrawn, and the blunt end fixed in the aperture thus made; the handle thus formed is pared away round the needle, and bound with fine silk or waxed cotton. The needle-points may be bent in any direction by heating them in the flame of a candle, and, whilst they are still hot, plunging them into water, or grease; their points are then ground on a hone. Glass rods (Plate XL. Figs. 9, 10) should be procured, and their ends drawn out to the requisite degree of fineness whilst strongly heated in the flame of a gas-lamp.

the cells of this part, offer. A little alcohol, added to the water in which these sections should be viewed (under a glass cover), will detach air-bubbles that generally form in them.

The form, position, and number of layers, or rows of cells, forming the substance of the leaf, the structure of veins, the presence of *cystolithes, raphides, starch,* or other matters contained in the cells, or intercellular spaces, the character of the *epidermis,* the structure of *stomates,* and the mode of attachment of *hairs* or *glands* to the epidermis, can be well studied in such sections.

The epidermis of the midrib and veins is in most cases easily detached by peeling it off with the forceps (Fig. 15): after making a slight incision with a sharp knife, that on the lamina requires a more careful treatment, and consists in making a very careful incision at the edge of a midrib, or vein, just above the angle formed by the junction of the laminar portion with it. By raising the outer film with the edge of the knife, and applying the forceps with a gentle tension of the part both forwards and laterally, the epidermis may be successfully detached without injury. Portions thus obtained are carefully laid out perfectly flat on a clean glass slide, with a camel's-hair brush dipped in water; water and a drop of caustic potash are then added; they are then covered with glass, and examined under the microscope. From other leaves, such as *Coltsfoot,* the epidermis is more easily detached by raising it in the manner described above, and inserting under its edge a very sharp knife (14), with which it is gently raised, carefully cut, and transferred to a slip of glass with water, to which a little alcohol is added. In other hard leaves, *Stinking Hellebore* for example, the epidermis of the lower side may be separated by snapping the leaf across; this will expose the edge of it for the application of the forceps. Should the lower stratum of the spongiform tissue of the leaf adhere to the epidermis, these cells may be detached by boiling

the specimen for a few minutes in water to which one or two drops of nitric acid have been added, when they can be removed with a needle-point.

When the epidermis of any leaf will not separate by either of the foregoing methods, recourse must be had to cutting into its substance on either side, and dissecting away the substance of the leaf down to the opposite side with a pair of cutting needle-points (Figs. 6–8). This operation is sometimes assisted by previously steeping the leaf in a weak solution of caustic potash.

Leaves with strong prickly hairs on their surfaces, such as *Comfrey* and *Sunflower*, require to be digested in very dilute nitric acid for some hours, or boiled in a weak solution of caustic potash. Those with a thick epidermis should be soaked in very weak caustic potash, and afterwards digested in alcohol. It should, however, be remembered, that caustic potash dissolves starch, and that alcohol decomposes or dissolves chlorophyll.

Very thin vertical sections of wood (Plate IX. Fig. 1), or of the midribs or veins of leaves, are obtained by cutting thin slices of them in the direction of their longitudinal growth (Fig. 14), either from the centre or the circumference. The true spiral vessel in these tissues may be distinguished from other forms of vessels by the unrolling of the spiral fibre when the ends of the vessel are dragged out by the aid of needle-points, which may be easily done on the stage of the dissecting instrument. By tearing in a lateral direction, the liber and wood-cells may be separated, and their forms more distinctly traced. Samples of snuff, or other finely-divided substances, should be examined under the dissecting microscope, for the purpose of separating and dissecting the larger particles with a pair of needle-points. These, according to their supposed structure, should be submitted to the action of suitable reagents under the Compound Microscope.

The following chemical reagents are recommended by Dr. Schacht* :—

I. "Alcohol, which is used for removing air from sections of wood and other preparations, and as a means of dissolving certain colouring matters, &c. This is also useful for producing the contraction of the primordial utricle.

II. "Ether, which is principally used for dissolving resins, fatty and other essential oils, &c. This is also useful for removing air.

III. "A solution of caustic potash, which is used for the purpose of dissolving fat. It is also very useful from its effects upon the contents of cells; it also acts as a solvent upon the cuticle, the intercellular substance, upon wood, and upon cork.

IV. "A solution of iodine (one grain of iodine, three grains of iodide of potassium, one ounce of distilled water), for colouring the cell-membrane and the contents of the cell.

V. "Concentrated sulphuric acid. This is principally used for examining pollen and spores.

VI. "Some diluted sulphuric acid (three parts of sulphuric acid and one of water), for colouring the cells of plants which have been previously moistened with the solution of iodine. The object is moistened with the solution of iodine, which is then removed with a fine camel's-hair brush, and by means of a glass rod (Figs. 9, 10) a drop of sulphuric acid is added, and the object is then immediately covered with a covering-glass. The effect of the sulphuric acid and iodine, as well as that of the iodized solution of chloride of zinc, is not always the same over the whole surface of an object. At the points where the mixture is more concentrated, the colouring is more intense; frequently places remain without any colour. The colour changes after some time; in twenty-four hours the blue is often changed into red.

* The Microscope, and its Application to Vegetable Anatomy and Physiology. London, 1855.

VII. "A solution of chloride of zinc, iodine, and iodide of potassium. A drop of this solution, applied to an object placed in a little water, produces the same colour as iodine and sulphuric acid. This solution was first recommended by Professor Schultz, of Rostock; it is more convenient to use than iodine and sulphuric acid, and produces almost the same results; it is, moreover, not so destructive as sulphuric acid. Sometimes, however, it fails to produce colour in cases in which iodine and sulphuric acid produce a blue tint in cellulose; iodine and sulphuric acid must therefore in many cases be used in addition to the above solution. The exact prescription for the solution is as follows:—Zinc is dissolved in hydrochloric acid; the solution is permitted to evaporate under contact with metallic zinc, until it attains the thickness of a syrup, and the syrup is then saturated with iodide of potassium. The iodine is then added, and the solution, when it is necessary, is diluted with water.

VIII. "A solution of sugar or weak syrup, to be used as a reagent upon nitrogenous matter. The preparation (animal or vegetable, as the case may be) should be saturated with the syrup, and then carefully removed with a camel's-hair brush. A drop of diluted sulphuric acid should then be applied with a glass rod. If nitrogen be present, the preparation, in the course of eight or ten minutes, assumes a more or less clear tint of a rose colour. If the colour is very faint, it sometimes disappears whilst the object is under the microscope, in which case it is a good plan to place the slide upon white paper, and the colour will then become visible to the naked eye. A weaker solution of sugar may be used for producing contraction of the primordial utricle.

IX. "Nitric acid, or, what is better, chlorate of potash and nitric acid: this is used for separating cells. The method of maceration discovered by Professor Schultz, and which is much to be recommended, is as follows:—The object (wood, for

instance) is reduced in size to the thickness of a lucifer-match; it is then thrown into a long and tolerably wide boiling tube; to this is added in a little while an equal volume of chlorate of potash, and as much nitric acid as is at least sufficient to cover the wood and the potash; the tube is then warmed over a spirit-lamp; a brisk development of gas quickly appears; the boiling tube is withdrawn from the flame, the oxidizing mixture is permitted to work for a minute and a half or three minutes, and the whole is thrown into a saucer with water; the small pieces, which adhere slightly to one another, are then collected, placed in the boiling tube, and boiled repeatedly with alcohol until the latter appears colourless; they are then boiled once more, for the last time, with water. The boiling in alcohol is always advisable, because it not only removes the turpentine, but also carries off the fluid residuum of the acid, which is apt to be injurious to the object-glasses of the microscope. By the help of the simple microscope the cells are now separated from one another with a needle, and selected. The boiling with nitric acid and chlorate of potash should never be carried on in the room where the microscope is kept, because its glasses might be injured by the evaporation which is developed. Thin sections of plants, for instance, of wood or leaves, are warmed for half a minute, or a minute, in a watch-glass; the boiling is unnecessary in this case; the section is taken out with a little rod, and thrown into a small watch-glass with water."

Care is requisite in boiling the mixture of nitric acid and chlorate of potash, on account of its explosive nature.

X. "Oil of lemons, or any other essential oil, for examining pollen and spores."

XI. Strong hydrochloric acid. This is warmed, and a drop applied by means of a glass rod (Fig. 10), for the purpose of detaching the *cuticle* from some hairs, as of *Sunflower* (Plate V. Fig. 21).

Tissues treated with the nitric-acid and chlorate-of-potash solutions are at times rendered so transparent as to be almost invisible. When this is the case, a drop of the iodine solution should be added to the water in which they are viewed.

Inuline, a substance analogous in its composition to *starch*, having the same refractive power as water, requires to be viewed in a different medium, such as oil.

Globules of oil, when surrounded by water (Plate V. Fig. 5), assume a *darker* appearance in *depressing* the object-glass, and become *lighter* on *raising* it. Water-globules surrounded with oil become lighter when the object-glass is *depressed* (Plate V. Fig. 6), and *darker* as it is *raised*.

The directions here given will, it is hoped, be found sufficient for any one commencing the use of the Microscope. Experience and reflection will bring with them many useful suggestions, which, if aided by *energy* and *patience*, will prove to the student "that nothing is denied to well-directed labour."

CHAPTER VII.

HISTORY, USE, CULTIVATION, AND MANUFACTURE OF TOBACCO.

In Eastern countries the custom of smoking is of unknown antiquity; but whether tobacco or other herbs, is not well ascertained. The natives of Mexico not only use tobacco as an article of luxury, but also to allay hunger and thirst, and as a remedy against all diseases. Among the Indian tribes of North America, from whom the plant has travelled to Europe, smoking is a ceremony of some importance. All their enterprises, declarations of war, or conclusions of peace, begin and end with smoking tobacco. The stems of the pipes (calumets) used on such occasions are adorned with the most beautiful feathers from the wings of birds, beads, and other ornaments interwoven with women's hair, thus giving them much the appearance of a Mercury's wand*.

The introduction and use of the herb in Europe date from a time posterior to the discovery of America by Columbus and his followers. On their arrival at Cuba, in 1492, they first beheld the custom of smoking cigars. According to Humboldt the seed was sown in Portugal as early as 1559. The herb was introduced into Spain in 1560, and into France in the same year by the French ambassador at the court of Portugal, Jean Nicot, who in the course of his mission forwarded some seeds, which he had procured, to the queen-mother, Catherine de Médicis. On his return from Portugal he presented the plant itself to her.

* History of Virginia, by a Native and Inhabitant. London 1722.

The honour of having thus enriched his native country has been disputed by the queen's almoner, Thevet, but with no success, as the name of Nicot is still associated with the herb in its botanical designation *Nicotiana.* The name Tobacco belongs to the language of Hayti, or St. Domingo*, and has been most probably derived from a word which designated the instrument or pipe used in smoking it, a term which was transferred by the Spaniards from the pipe to the herb itself.

From France the herb was sent to Italy by the Pope's Nuncio, Sainte Croix. It was from this circumstance also known as "*the herb of Sainte Croix.*"

The introduction of Tobacco into England took place in the reign of Queen Elizabeth, who, on 25th March 1584, granted to Sir Walter Raleigh a patent for the possession of any countries he might discover in North America. Of this privilege Raleigh immediately availed himself, and fitted out several vessels at his own expense to take possession of a newly-discovered and fertile country then named *Windangocoa,* but afterwards christened by Queen Elizabeth by the more euphonious title of Virginia, in allusion to her own virginity. To Sir Richard Grenville, Sir Walter's kinsman, was given the command of the expedition and the future colonists of the newly-discovered country. Grenville left a number of them at a place called Roanoak, or Roanoah, in North Carolina, under the command of Ralph Lane. This was in the spring of 1585. In the autumn of the following year, these colonists, who appear to have suffered both from the attacks of the native Indians and from famine, availed themselves of the arrival of Sir Francis Drake (then on his return from attacking the Spanish possessions of Carthagena and St. Domingo) to make their escape back to England in his ships, and on embarking brought with them the tobacco-plant.

In 1587 Raleigh sent another draft of 150 men, with John

* Humboldt, Essai politique sur le Royaume de la Nouvelle Espagne.

White* as governor, and twelve assistants, to Virginia; and it was from this colony that he first imported Tobacco into England. He also about this time obtained 12,000 acres of forfeited lands in the counties of Cork and Waterford, on which he introduced the cultivation both of the potato and tobacco plants.

It was obviously Raleigh's interest to improve the cultivation of his newly-acquired possessions, and to raise a demand for their produce. It is not therefore surprising that he took to smoking, nor that he did his best to make the practice fashionable. We accordingly read that the "ladies, and great and noble men," of Queen Elizabeth's court, "would not scruple to blow a pipe sometimes very sociably†." Whether the virgin queen participated in the recreation is not made evident.

We catch a glimpse of Raleigh's cultivation of the art of smoking in the anecdote which is told of him, that having dispatched his newly-appointed servant for some beer, he in his absence lighted his pipe and began smoking. When the servant returned, he was thunderstruck at seeing dense volumes of thick smoke proceeding from his master's mouth, and thinking that his body must be on fire, in order to extinguish it, dashed the beer in his face. At Sir Walter's house at Islington he frequently entertained his guests, the only refreshments offered to them being a mug of ale with nutmeg, and a pipe. With such homely cheer did our courtly forefathers regale themselves! In less prosperous times, when a state prisoner in the Tower, Raleigh doubtless found no small solace in his favourite herb.

By Elizabeth's successor, James I., tobacco was not thought so palatable, for he not only refused "its precious stinke," as he called it, but endeavoured, in his famous "Counterblast," to restrain the use of it by his subjects, on the plea that it made

* Hakluyt's Voyages.

† Biog. Britannica, art. *Raleigh*.

their bodies weak and unfit for labour. In 1604*, without the consent of his Parliament, he issued a royal warrant, raising the tax on the commodity from two pence to six shillings and ten pence for every pound value,—a measure to which he was prompted perhaps as much by his hatred of tobacco as by his jealousy of the increasing prosperity of the Spanish West Indies, from whence all the tobacco imported into this country was sent.

In Italy, Pope Urban the Eighth issued a bull, threatening excommunication to all those using tobacco in churches; the king of Persia and the Czar of Muscovy forbade its use, under pain of death, with the mild alternative of having the nose cut off for taking snuff.

What was left undone by James in prose, was intended to be accomplished some time after in poetry by Joshua Sylvester, who wrote some verses entitled,—"Tobacco battered, and the pipes shattered, (about their ears who do idly idolize so base and barbarous a weed, or at least-wise overlove so loathsome a vanity). By a Volley of Holy Shot from Mount Helicon †."

The following is not an unfavourable specimen of Sylvester's style:—

> "If Solomon, the Wisest earthly Prince
> That ever was before, or hath bin since,
> Knowing all Plants, and them perusing all,
> From Cedar to the Hyssop on the wall,
> In none of all professeth that he found
> A firme Content, or Consolation sound,—
> Can we suppose that any Shallowling
> Can find much Good in oft *Tobacconing*?"

Of Tobacconists, as he calls the smokers,

> "For as of all Insensibles, hath none
> More Melancholie and Adustion

* Anderson's History of Commerce. London, 1785.
† London, 1641.

Then Chimnies haue; what kind of Chimney is 't
Lesse sensible than a *Tobacconist*?
And in receiving Smoake, sith th'are so equall,
Can their Adustion then be much unequall?
Thus then the habit of *Tobacconing*
Makes one more Chimney-like than anything."

The author concludes:—

"But awfull Justice will with keener edge
Clip short (I hope) this sawcie Priueledge,
And at one Blowe cut-off this ouer-Drinking
And ouer-Dropsie of Tobacco-stinking."

In spite of James's opposition to the use of tobacco, it continued to become more popular, and had considerably increased after the foundation of James Town in 1607. In 1610 he granted a charter to the Virginia Company, and the possession of all the islands on the coast of South Virginia; it may therefore be supposed that there were very many in England interested at this time in the welfare of that colony, the soil of which was admirably adapted for the growth of tobacco. Ten years after this date (in 1620) James's attention was attracted to the "drug called Tobacco." He had at this time taken to himself the pre-emption of all tobacco imported; and considerable quantities of it were being sent from Virginia, the colonists, as he complained, having so overstocked the market that he could not afford to give them more than three shillings a pound for it. Out of pity to the country, the king likewise commanded that the planters should not make more than one hundredweight per man, and forbade its importation by any but those holding his letters patent to do so*. To make this monopoly still more valuable, the growth of tobacco in Ireland was forbidden, in 1624, and the importation of foreign tobacco altogether prohibited.

In 1625 James died, and his successor Charles I. imme-

* History of Commerce.

diately commenced tobacco merchant and monopolist, and, under the pretext that it would be beneficial to the plantations and the owners therof that their management should be all brought under one hand, created a monopoly of it, and by this means was enabled to enhance the price of it at his pleasure. To make his monopoly more complete, he formed a commission of the aldermen, &c. of London to carry out his proclamation, and to seize all foreign tobacco not of the growth of Virginia and Bermudas, for his benefit; and in the same month he published his permission for 50,000 lbs. of Spanish tobacco to be imported; but then it was to be all bought by himself, and re-sold to his subjects *.

We have Camden's assertion, that about this time tobacco was highly prized, both for smoking as a recreation, and as a health restorative, for he says that "with inexpressible greediness they sucked in through an earthen pipe its excessively stinking smoke, which they afterwards blew out through their nostrils, insomuch that tobacco-shops are not less frequent in towns than ale-houses and taverns †."

In 1627 the king enjoined the plucking up of all tobacco found growing in England and Ireland, and restricted the importation from Spain and foreign countries to the port of London only, and under a special licence, to be granted by him, to whom it was to be delivered at a reasonable price. It was also enjoined in the proclamation, that no person was to buy any tobacco but of the king's commissioners; and when resold, a note was to be kept of the transaction. These restrictions Charles re-enforced in 1630; and after inveighing in his own and his father's usual manner against the inordinate use of tobacco, which he styles "an useless weed," he proclaimed that the

* History of Commerce.

† Camd. Annales Rer. Anglica.; cited by Clarke, "Dissertation on the Use and Abuse of Tobacco."

quantity to be imported from Virginia, the Somer Isles, and Caribbee Islands was to be regulated by himself: and in the year following he expressly prohibited "keepers of taverns, ale-houses, inns, and victualling-houses, strong-water sellers, &c. from retailing tobacco," which was confined to "reputable and substantial traders." "How little," observes Anderson, "in this, as in many other respects, did he understand his true interests!"*

Maryland (so named in honour of the queen, Henrietta Maria) was granted to Lord Baltimore in 1632, who in the year following took out with him 200 persons to that colony; and the cultivation of tobacco went on rapidly.

When the king found his revenue fast increasing by the monopoly and the custom on tobacco, he began to think less harshly, it is presumed, of its use by his subjects; but as their temper was not yet broken, he bethought him of placing common brewers, maltsters, the stampers of cards and dice, proprietors of hackney carriages, and the makers of soap, under a like monopoly. It was not until 1640, when Parliament met, and requested the redress of grievances in return for the subsidies that the king required of them, that he was willing to relinquish the monopolies "for compounding with offenders touching tobacco, *i. e.* such as sold it without the king's stamp†." These grants, patents, and monopolies, which included the "licensing of brewers" and "the gauging of red herrings," were then worth to the king £200,000‡.

The Parliament sitting at Westminster in 1643, on 16th May of that year, issued an ordinance imposing a tax on beer and ale in all counties within the limits of their power, calling it by a new word, *Excise*; and at the same time a tax of 4*s*. was imposed on the pound value on foreign, and 2*s*. on English plan-

* History of Commerce. † Ibid.

‡ Royal Treasury of England, quoted by Anderson.

tation tobacco, which was also taxed at fourpence per pound weight *.

About the middle of the seventeenth century considerable quantities of tobacco were being grown in several counties in England, which was at length prohibited by the Rump Parliament and Oliver Cromwell. The first legal prohibition dates from 1660 (12 Car. II. c. 34), the preamble of which states, that the planting of tobacco in England and Ireland was depriving the king of a considerable part of his revenue. The Act imposed a penalty of £10 for every rood or pole of land in England, Ireland, Jersey, or Guernsey, planted with tobacco, excepting in the physic garden of either University, or other private gardens for surgery, so that the quantity does not exceed half a pole in any one garden. Nevertheless the planting still continued; an Act was therefore passed (22 & 23 Car. II. c. 26), in which peace-officers were directed to search for and prevent tobacco growing within their jurisdiction, and to destroy it when found, physic gardens being, as before, excepted. A clause was inserted in the Act, in which the landing of tobacco in England was required, before being conveyed elsewhere. Ireland was thus precluded from the commerce of tobacco, excepting by means of a previous landing in England.

This Act, and others by which it was confirmed in the reign of George III., had not the desired effect of entirely stopping the growth of the plant in England, large quantities of it being grown in the vales of York and Ryedale a few years prior to 1782. The cultivators at York had their tobacco publicly burnt, and themselves severely fined and imprisoned: penalties, it is said, were paid to the amount of £30,000. This put a stop to the illegal cultivation of tobacco in England. The growth of tobacco in Ireland was not finally prohibited until the passing of the Act 1 & 2 Will. IV. cap. 13, in the year 1831.

* History of Commerce. Cobbett's Parliamentary Hist. vol. iii. p. 114.

In the first year of the reign of James II. (1685) an Act was passed granting to him the duties arising on tobacco, on which, over and above all other charges, a tax of three pence per pound weight was levied. Anderson observes that this was the first time that the tobacco and sugar of our own colonies were particularly taxed by name, until now the tax being in the form of a poundage on all imported goods*.

It was about this time that the French king, Louis XIV.†, by his revocation of the edict of Nantes (which gave religious toleration to the Protestants of France), drove three hundred thousand of his people out of the kingdom, many of whom fled to England and Holland. To this circumstance England owes the silk manufacture of Spitalfields, as Holland is indebted to it for a more extensive cultivation of tobacco. The persecutions carried on both by Charles and James against the Dissenters undoubtedly did something for the colonies of Virginia, Maryland, and Carolina; for we find that in the year 1702 there were no less than 20,000 souls in the adjoining districts of East and West New Jersey, who had been terrified thither by the harsh proceedings threatened against them in the reigns of these monarchs‡.

* History of Commerce. † Voltaire, Age of Louis XIV.

‡ An Account of the First Settlement of the Provinces of Virginia and Maryland, New York, &c. Lond. 1735.

The prosperity of these colonies and the history of the United States are inseparably connected with the consumption of tobacco in this and other countries. From 1772 to 1775 North America exported annually about 100,000 pounds of tobacco, 12,500 pounds of which were consumed in the United Kingdom, the remainder in Europe. From 1787 to 1789 the annual quantity exported was 89 millions of pounds, of which 8 millions of pounds were consumed in the United Kingdom. In 1855 there were 30,114,730 pounds weight of unmanufactured tobacco entered for home consumption in the United Kingdom, 24,185,959 pounds of which were received from the United States. The duty has fluctuated from 10*d.* in 1786 to 1*s.* 3*d.* in 1787, to 1*s.* 7*d.* in 1796, gradually to 4*s.* in 1819, and to 3*s.* $1\frac{8}{10}$*d.* in 1842, which is the present rate.—M'Culloch's Commercial Dictionary. Trade and Navigation Report, 1856.

Lord Macaulay's description of the London coffee-rooms gives a lively picture of the manners of the people in the reign of James II. The historian says that "in general the coffee-rooms reeked with tobacco like a guard-room; and strangers sometimes expressed their surprise that so many people should leave their own firesides to sit in the midst of eternal fog and stench."*

There are several papers in the 'Spectator' illustrative of the customs of smoking and snuffing in the year 1711. In one of these the snuff-box is ironically alluded to by Steele as a rival to the fan, at that time a fashionable appendage to ladies' dress: in another, he protests against the use of "good Brazil in the middle of a sermon†."

> "To such a height with these is fashion grown,
> They feed their very nostrils with a spoon ‡."

The practice had not abated eighty years afterwards, for Clarke complains of the handing round of the snuff-box in churches and chapels during divine service, "to the great scandal of religious people." Chewing must have been nearly, if not quite as popular, for he adds, "kneeling in prayer is prevented by the large quantity of tobacco saliva which is ejected in all directions §."

So late as the year 1725, the healing and medicinal properties of tobacco were praised in verses which Dr. Clarke has transferred to his pages in his Dissertation on the use and abuse of the herb. From this panegyric it would appear that the various complaints in which it was at that time considered efficacious ranged from sore eyes to diseases of the lungs. The modern practice of medicine has reduced its uses within much narrower limits; and modern chemistry has discovered amongst its constituent ele-

* Hist. of Eng., new edit. vol. ii. p. 383.

† See, among others, Nos. 49, 138, 344.

‡ Poems on several Occasions. By Sam. Wesley. Lond. 1736.

§ Dissertation on the Use and Abuse of Tobacco. 1797.

ments the presence of a poisonous principle (*Nicotin*) as powerful almost in its effects as prussic acid, and an empyreumatic oil, one drop of which, placed on the tongue of a cat, produced convulsions, and death in two minutes*.

A great part of the tobacco consumed in Europe is grown in Virginia, Maryland, and other parts of the United States, and in France and Holland. As the plant requires a good, rich soil, and arrives at its greatest perfection in climates of the temperate zone, between 40 and 47 degrees of latitude, there is but little variety in the methods pursued in its cultivation in those countries in which it is grown †.

The plants are raised from seed in beds prepared with rich manure, wood-ashes, and fine earth, and protected from the north wind. The seeds are usually mixed with fine sand or gravel, and sown by means of a sieve, which prevents their lying too closely together. In nine or ten days from the time of sowing (the month of March), the young plant makes its appearance above ground. From this time it is subject to the attacks of grubs, insects, snails, and worms, which are got rid of by various expedients, such as a mixture of salt and earth, or soot, or lime, which is sprinkled over the beds. The attacks of the fly are guarded against by planting white mustard-seed around the beds, the plants from which attract the insect in preference to those of tobacco. Frost, which is particularly destructive to the young plants, is excluded by placing straw, fern, or matting over them.

In about two months, when the young plants have sprouted

* Pereira, "Elements of Materia Medica and Therapeutics."

† Don, in his "Gardener's Dictionary," enumerates above forty species of the plant, most of which are considered at the present day to be varieties only. The three species that are most commonly grown are named on page 32.

their fourth leaf, and the fifth begins to appear, they are fit for transplanting. The tobacco-ground, or field, is laid out in narrow beds richly manured, each bed being 2 feet wide at top and 2 feet 6 inches at the bottom ; the space between them being about 8 inches, which serves as a drain for the beds, and for a path from which their surfaces may be hoed and weeded. For the operation of transplanting, advantage is taken of a moist day, and is performed as quickly as possible some three or four hours after the sun has declined from its vertical position. Each plant is carefully removed from the bed, and placed in a hole made to receive it; the earth is then gently pressed around its roots, after which it is watered. In this way the beds are all laid out with plants 2, 3, or 4 feet apart.

The greatest care and attention are now requisite for the succeeding eight or ten weeks, during which time the plants enlarge and come to perfection. Those that have not struck properly are removed, and their places filled by fresh plants from the bed. Others flourish well for a time and then droop,—a sure sign of the presence of a worm or grub at their roots, which is either dislodged by moving the earth and destroying the enemy, or, if his attacks have been too vehement, by removing the plant, and, if time allows, replacing it with another. Canker is a disease to which the tobacco, like the hemp-plant, is liable. This is caused by a parasitic plant, *Orobanche ramosa,* which attaches itself to the root and chokes its growth. Rust is another destructive enemy to the plant, in deteriorating its leaves. This appearance is caused by small globules of water deposited from the dew at sunrise, and which from their lenticular form produce the effect of a double-convex lens, in causing the sun's rays to converge to a focus, burning that part of the leaf on which they strike.

Watering, weeding, and hoeing up the earth at the base of

the stem, and the destruction of a caterpillar which feeds greedily on the leaf of the plant, are operations of frequent occurrence for six or eight weeks after transplanting.

There are three sorts of tobacco, known among cultivators as *strong*, *medium*, and *mild*. The first quality among these is represented by the leaves which are nearest to the root; the second, by those at the middle of the stem; and the third, by those at its summit. According to the required quality of the crop, the planter regulates the number of leaves that shall be allowed to grow on each plant. For this purpose he arrests its upward growth by nipping off the top, and thus directs the energies of the plant and its juices into the leaves; with this object in view, they are also deprived of the buds which form in the axils of their leaves*. Plants that have been successfully cultivated are in this way made to yield either ten or twelve leaves, varying in length from 25 to 30 inches, of *strong* flavour; or fifteen leaves, from 20 to 25 inches in length, of *medium* flavour; or twenty leaves, 12 to 20 inches long, of *mild* tobacco †.

When the leaves of the plants change their colour and become less brittle, and more or less mottled in appearance, they are fit for gathering. In some countries the harvest operations are repeated two or three times; for instance, by depriving the plants first of all those leaves which are at the bases of their stems; then, in eight days afterwards, of those about the middle; and finally, those at the summit, after the lapse of another eight or ten days. The more common practice is to cut the stems of the plants close to the ground, and to lay them on the beds in the sun to dry, until the evening; they are then carried to the drying-house and laid in heaps to sweat, and covered with mats to keep-in the heat, and left for several nights to soften and bleach. The leaves being now supple, are either stripped

* This is called "succouring" the tobacco.

† Joubert, "Tabac."

from their stems, and strung together on packthread or switches, or the plants are suspended in rows on pegs fixed on laths which run across the drying-house, allowing sufficient room for the air to circulate among them. When quite dry, and when the weather is damp, the plants are removed from the drying-shed and placed on hurdles, in heaps, covered over, and left for a week or two. During this time they are frequently examined and turned, to prevent too strong a fermentation that would destroy the juices of the leaves, which, if left to themselves, would take fire. The proper degree of heat is ascertained by thrusting the hand into the heap, which, with a skilful grower, is a far more delicate test than any thermometer. When the fermentation is complete, the leaves are separated from the stems and sorted, according to their different qualities. These being redried, are tied together in bundles of ten or twelve in each, and placed in regular layers (the position of the leaves being reversed in each layer) in barrels or hogsheads. As each layer is formed, it is covered with a round board fitting the interior of the hogshead, and a pressure equal to 4000 lbs. weight or more is brought to bear upon it. By this means the leaves are compressed into a solid mass, and the air is excluded from them, which is necessary for their good keeping during a sea-voyage.

The finest tobacco is exported from America in 'carrots,' as they are called. These are made by depriving the leaves of their midribs, placing them together in large handfuls, and binding them round tightly with fibrous wood, or strong grass, at a time when the air is moist.

The roll tobacco of the Rhine is made from green leaves which have not been stored. By the processes of twisting and rolling which they undergo, they acquire the necessary dryness.

The expense of cultivating a hectare (nearly 2 acres) of land in France with tobacco is stated by M. Joubert to be, in English

money, about 32*l.* 1*s.* 8*d.*, and the produce on an average 86*l.* 5*s.*, leaving 54*l.* 3*s.* 4*d.* net for profit. In successful seasons, 67*l.* or even 70*l.* profit may be realized.

In the United States, all tobacco, previous to its sale, is submitted to public inspectors, who condemn it to be burnt if badly prepared or otherwise damaged, the loss falling on the owner.

The manufacture of tobacco-leaves into those forms in which it is consumed, either in *smoking*, *chewing*, or *snuffing*, consists either in cutting the leaf into shreds, folding it in the form of cigars, twisting or spinning it into ropes, or grinding it into powder.

Before any of these operations can be performed, the leaves are placed in heaps and moistened with water*.

In "cut" tobaccos, other than that known as *bird's-eye*, the leaves, after being moistened, are deprived of their midribs,—an operation that is performed for the most part by women and boys with considerable dexterity. The masses of sorted and stripped leaves are then mixed in the required proportions, occasionally moistened, and pressed together by machinery in the form of a cake. From the presses they are transferred to the cutting-machine, moved generally by steam. The cake of leaves is laid upon an iron bed which is susceptible of a slow progressive motion by means of a screw, which passes beneath

* In Great Britain, by 5 & 6 Vict. c. 93, no matter or thing is allowed to be added to the water used in the manufacture of tobacco other than water, or water and salt, or alkaline salts only, or lime-water in snuff known as Welsh or Irish snuffs; under a penalty of £300. In France the practice is different. M. Joubert, in his work "Tabac," gives the proportion of 10 lbs. of marine salt to 100 lbs. of water, 2 lbs. of this solution (*sauce*) being sufficient for 100 lbs. of leaves, according to their unctuosity. At the present day (this author observes), *sal-ammoniac*, or *syrup*, is used instead of, or added to, the marine salt. He adds, that salt mixed with water is necessary to prevent any alteration or putrid fermentation in the leaves.

it, and is connected with a cog-wheel in such a manner that, while the machine is moving, the bed is constantly urged forward. Another part of the mechanism gives motion to a knife which has a sharp blade, rather longer than the width of the cake, and is pivoted on a hinge or fulcrum at one end, the other rising and falling with the action of the machinery. The depth of the cake is about 2 inches; and the thickness of the film taken off, and, consequently, the fineness or coarseness of the tobacco, is regulated by alterations in a train of cog-wheels, adjusted by means of a screw. In the manufactory at Paris there are ten such machines, worked by steam, which cut up at the rate of 14,000 lbs. of tobacco per day. These cuttings are exposed on a copper, or metal plate, to a gentle heat, being at the same time frequently turned over and pulled with the hands, and, when sufficiently crisp, they are slightly fermented, and either stored, or sent into consumption as 'cut' tobacco. For 'bird's-eye tobacco' the midribs of the leaves are retained, and it is the fancied resemblance of their cross sections to the eye of a bird that has given rise to the name.

Shag tobacco is chiefly prepared from the Virginian and Kentucky leaves. *Returns*, from the small pieces of broken leaf produced in the various processes of manufacture. *Canaster*, or *Kanaster*, received its name from *canastra* (a Spanish word signifying a basket) because it was imported in baskets. It is prepared from Varinas, German, Dutch, or Havannah leaf. *Maryland*, *Orinoco*, *Turkey*, *Persian*, and *Varinas*, are other forms of cut tobaccos.

'*Twist*' or spun tobacco is made by forming the leaves into long cords or ropes of various thickness, and is either performed by hand, by a wheel, or by both. When spun by hand, the leaves, deprived of their midribs, are twisted together in lengths of about 3 feet, which are then skilfully joined so as to conceal the points of union. When performed by the wheel, the opera-

tion requires a man and two or three boys. A long narrow bench is provided at one end with a spinning-wheel, which is turned by one of the boys, whilst the other lays out the damp leaves, smooth and open, along one side of the bench. These, the man, as he comes to them, twists together, and, with a flat piece of wood held in the right hand, gives to the cord thus formed a peculiar motion, the effect of which is to bind the whole firmly together. As the end of the bench is reached, the rope is wound on the spinning-wheel, and the man begins again. The rope, when of sufficient length, is transferred from the spinning-wheel, by the action of machinery, to a frame connected with it, and subsequently wound or twisted into a hard, close ball, by rolling it several times on itself. The twists are placed very closely together, so as to exclude air. During this operation the workman moistens the rope with sweet-oil, and drives small wooden pegs into it at intervals on each coil. The rolls thus formed are then submitted to enormous pressure in presses worked by hand with screws and levers. Each roll, either before or after being pressed, is cased in paper or coarse linen, and kept until it has acquired sufficient maturity by age. Tobacco so manufactured is also known as 'pig-tail,' and in this form it is served out in the English navy.

Cigars and *cheroots* are formed of the leaves of tobacco deprived of their midribs, and rolled so as to allow the air to percolate through them. The operation is a very simple one. After the leaves have been sorted and moistened, and in this state left for some hours, they are 'stripped,' or deprived of their midribs, the best among them being selected for 'outsides,' or covers; those next in quality as 'bunch-wrappers.' The first operation of the workman is to cut a bunch-wrapper from a leaf, in the form of one of the gores or stripes of a balloon. On this he places some fragments of leaf (usually the cuttings left in other processes of manufacture). These are the 'fillers,'

round which the bunch-wrapper is rolled into the form of a cigar. The next operation consists in placing the cigar against a gauge of the required length, and cutting it, after which the outside is rolled spirally round it, and the pointed end pasted or gummed. The cigars are set aside to dry, a process generally aided by artificial heat. Cheroots have both ends cut, or truncated, but they are made in the same way as cigars.

For *snuff*, the midribs only of the leaves, or a mixture of these and the softer parts, are cut into small pieces, spread on the floor, and sprinkled with water*. The 'batch' thus prepared is placed in bins, and there suffered to ferment for a considerable time (varying from two months to as many years), during which it is occasionally turned to prevent over-heating, and again moistened. When this process is completed, it is sent to the mill and ground, either between stones, or by hand in a mill worked with a motion similar to that which is given to a pestle in a mortar.

The 'high-dried' Scotch and Irish snuffs are prepared in great part from the midribs alone. These, after being cut and fermented in the usual way, are placed in shallow metal pans or trays before a brisk fire, and strongly heated. During this operation they evolve a great quantity of ammonia.

The Strasburg, French, and Russian 'moist' snuffs are prepared principally from the soft parts of the leaves. *Moistening* and *scenting* are subsequent operations, to which most of the snuffs in common use owe much of their pungency and other attractive qualities.

The following are the principal places from which tobacco finds its way into the English market:—

Europe.—*Germany, Holland,* and *Salonica,* in European Turkey.

Asia.—*China, East Indies, Latakia,* and other parts of

* See note on page 119.

Asiatic Turkey; *Shiraz* in Persia; *Manilla* in Luzon, one of the Philippine Islands.

North America.—*Virginia, Kentucky, Maryland.*

The Islands of *Cuba, Hayti,* and *Porto Rico.*

South America.—*Varinas, Brazil, Columbia,* and *Cumana.*

Cuba, Havannah, and the Columbian leaf tobaccos, *Columbian, Varinas,* and *Cumana,* are the most esteemed for cigars. The leaves are marked with light yellow spots.

The *Virginian, Kentucky,* and *Maryland* tobaccos are more frequently used for cut and spun tobaccos. *Turkey, Latakia,* or Syrian tobacco, and the *Persian,* or *Shiraz* tobacco, are among the mildest and most delicately-flavoured for the pipe.

The Dutch tobaccos are mild, and deficient in flavour. The darker kind is the strongest, and much esteemed for moist snuffs, the weaker kinds being employed in the commonest cigars and cheroots.

Manilla tobacco is much esteemed for cheroots.

Mixture of the leaves produced in different countries gives great variety in the flavour of manufactured tobaccos, requiring considerable skill and attention on the part of the manufacturer.

The subjoined extract from a wholesale Price Current list will show the different kinds of raw and manufactured tobacco sent to this country, the form of packages in which it is imported, and the countries to which it is exported :—

W—— C—— & CO.'S PRICE CURRENT.

(Wholesale.)

London, October 1st, 1857.

		Prices.				
		s.	*d.*		*s.*	*d.*
Virginia Leaf.						
Fine Spinners	per lb.	0	11½	–	1	0
Good middling ditto		0	9½	–	0	10½
Ordinary and Faded		0	0	–	0	8
For fine Shag and part Spinning		0	0	–	0	11
For common ditto		0	0	–	0	0
Fine black sweet-scent		0	0	–	0	0
Middling ditto		0	0	–	0	0
Yorks		0	0	–	0	0
Middling ditto		0	0	–	0	0
Stemmed Spinning, fine						
Good middling		1	0	–	1	2
Middling						
Common (short and faded)						
Kentucky Leaf.						
Fine		0	11	–	1	0
Middling		0	8	–	0	9½
Ordinary		0	0	–	0	0
Stemmed, fine						
Good and leafy		1	0	–	1	3
Ordinary						
Maryland.						
Fine Yellow		0	0	–	0	0
Yellow		0	0	–	0	0
Coloury		0	0	–	0	0
Light brown and leafy, scarce		0	9	–	0	9½
Brown and leafy		0	6¾	–	0	7½
Ordinary and part heated		0	0	–	0	0
Negro Head.						
Old and heated (none)		0	0	–	0	0
Good		0	9	–	0	11
Fine		1	1	–	1	2
Barret's fine Twist		1	6	–	1	7
Cavendish		1	0	–	1	1

Paraguay	per lb.	0	10	–	0	10½
Giron Leaf	,,	2	0	–	2	3
Varinas or C'naster (in bales about 90 lbs.)	,,	1	0	–	2	0
Brazil Leaf	,,	0	6	–	0	7½
St. Domingo Leaf	,,	0	0	–	0	0
Porto Rico Leaf	,,	0	5	–	0	7
Turkey ditto	,,	0	9	–	1	0
Havannah	,,	1	3	–	5	0
East India Leaf	,,	0	0	–	0	0
Havannah Cigars, in Bond	,,	9	0	–	20	0
Manilla Cheroots	,,	6	0	–	7	0
Cuba Tobacco	,,	0	11	–	1	0
Columbian ditto in Rolls....(none)	,,	0	0	–	0	0
Ditto in Leaf	,,	0	10	–	2	6
German Leaf	,,	0	6½	–	2	0
Yara Leaf	,,	1	3	–	3	0
Amersfoort for Cigars and Snuff	,,	0	8	–	0	10
Java	,,	0	10	–	1	0

		s. d.		s. d.
Kentucky Stalks	per lb.	3 0	–	3 1
Virginia Stalks	„	0 0	–	3 2
Mixed ditto	„	2 9	–	2 10
Smalls	„	2 8	–	3 0

IMPORTS.

71 Cases German	ex Seine @ Boulogne.
79 Bales „	ex Ceres @ Rotterdam.
99 Cases Cigars	ex Railway @ Southampton.
332 Serons Columbian	ex Railway @ Southampton.
38 Hhds. Tobacco	ex Railway @ Liverpool.
254 Bales Turkey	ex Railway @ Liverpool.
2 Cases „	ex Railway @ Liverpool.
778 Serons Columbian	ex Railway @ Liverpool.
100 Bales Greek	ex Railway @ Liverpool.
29 Bales German	ex Railway @ Liverpool.
2 Cases „	ex Lutcheon @ Hambro'.
1021 Bales Turkey	ex Elena @ Constantinople.
13 Cases German	ex Moselle @ Rotterdam.
3 Cases Cigars	ex Norma @ Constantinople.
5 Cases Cheroots	ex Jennie @ Batavia.
47 Bales Java	ex Jennie @ Batavia.
4 Cases German	ex Rainbow @ Rotterdam.
3 Cases Cigars	ex Rainbow @ Rotterdam.
1 Case Cheroots	ex Lord Raglan @ Calcutta.
33 Bales Manilla	ex Fyenoord @ Rotterdam.
10 Hhds. German	ex Fyenoord @ Rotterdam.
1 Case Cheroots	ex City of Tanjore @ Calcutta.
8 Cases German	ex Stadt Dordrecht @ Rotterdam.
146 Serons Columbian	ex East Anglian @ Antwerp.
1 Case Cheroots	ex Confucius @ Shanghae.
1 Case Tobacco	ex Baron Osy @ Antwerp.
38 Bales Paraguay	ex Aries @ Buenos Ayres.
65 Boxes Cavendish	ex Argo @ New York.
6 „ „	ex Railway @ Cardiff.

DELIVERIES FOR EXPORTATION.

Virginia, Kentucky, &c.	Hhds.	188
Maryland	„	1
Varinas Roll	Seron	—
Snuff	Case	—
St. Domingo	Serons	—
Amersfoort, German and Dutch	Cases	7
Havannah and Cuba Leaf	Bales	9
Cigars and Cheroots, all sorts	Cases	41
East India Leaf	Cases	—
Negro Head and Cavendish	Kegs and Tierces	269
Manilla Leaf	Cases	85
Columbian Tobacco (Leaf and Roll)	Serons	1279
Brazil Leaf	Bales	—
Seed Leaf	Case	—
South American (Leaf) Varinas Roll	Bales	7
Porto Rico, &c.	Bales	—
Turkey	Bales	113
China	Bales	—
Snuff		—
West India Leaf		—
Florida		—
Java		—

EXPORTATION.

Virginia, Kentucky, and Maryland.	Cigars and Cheroots.	Havannah, Cuba, Columbian, &c.	Where shipped to.
5	—	—	Cape Palmas.
15	—	—	Gibraltar.
80	—	—	Lisbon.
11	—	5 S. A. 28 Col.	Rotterdam.
1	—	—	Sierra Leone.
4 1 M	—	4 do.	Rio Janeiro.
2	—	5 Dutch. 9 Hav. 608 Col.	Antwerp.
14	—	12 Neg.	Guernsey.
—	—	1 do.	Madras.
—	9 cig.	4 do.	Port Phillip.
—	—	5 do.	Swan River.
—	—	1 do.	Batavia.
—	1 cig.	64 do.	Calcutta.
—	—	71 do.	Sydney.
—	—	1 do.	PuentaArenas.
—	1 cig.	32 do.	Hobart Town.
—	—	5 do.	Colombo.
—	3 cig.	4 do.	Cape of Good Hope.
—	1 cig.	1 do.	Malta.
—	—	3 do.	Van. Island.
—	—	2 do.	Bombay.
—	2 cig.	3 do.	Melbourne.
—	—	1 do.	Portland Bay.
—	—	1 do.	Algoa Bay.
—	—	1 do.	Launceston.
—	—	7 do.	Auckland.
—	—	6 do.	Calais.
—	—	22 do.	Adelaide.
—	—	2 do.	Hong Kong.
—	—	1 do.	Callao.
—	—	1 do.	Geelong.
—	—	1 do.	Valparaiso.
—	—	2 Dutch.	Gd. Canaries.
—	2 cig.	164 Col.	Bremen.
—	2 cig.	—	Riga.
—	5 cig.	447 do.	Hambro'.
—	3 cig.	—	Jamaica.
33	5 cig.	—	St.Petersburg.
23	3 cig.	2 S. A. 28 Col. 113 Turkey. 85 Man.	Amsterdam.
—	1 cig.	—	Montreal.
—	3 cig.	—	Buenos Ayres.
—	—	10 Neg.	New Zealand.
—	—	7 do.	Sundry Stores.
188 1 M	41 cig.	1279 Col. 269 Neg. 113 Turkey. 85 Man. 9 Hav. 7 Dutch. 7 S. A.	

BONDING.

Virginia, Kentucky, and Maryland.	Cigars and Cheroots.	Havannah, Cuba, Columbian, &c.	Outports.
3	—	12 Dutch.	Exeter.
74	—	4 Neg.	Newcastle.
1	11 cig.	17 do.	Southampton.
6	2 cig.	—	Dublin.
16	—	4 Neg.	Plymouth.
5	—	—	Waterford.
4 3 M	— —	31 S. A. 22 Tky.	Boston.
1	—	28 S. A.	Skibbereen.
1 M	—	1 do.	Devonport.
—	1 cig.	2 Neg. 30 Man.	Shields.
—	—	3 Neg.	Belfast.
—	—	1 do. 20 Tky.	Hull.
—	—	1 Neg.	Falmouth.
—	3 cig.	2 do.	Liverpool.
—	—	14 do.	Portsmouth.
—	—	1 do.	Stockton.
—	—	6 do. 4 S. A.	North Shields.
—	—	4 Neg.	Cardiff.
—	—	19 S. A. 1 Hav.	Gainsborough.
—	—	5 S. A. 50 Tky.	Manchester.
110 4 M	17 cig.	12 Dutch. 39 Neg. 88 S. A. 92 Tky. 30 Man. 1 Hav.	

INDEX.

THE END.

PRINTED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET.

AMERICAN TOBACCO.

London Published by John Van Voorst Paternoster Row 1858

SYRIAN TOBACCO

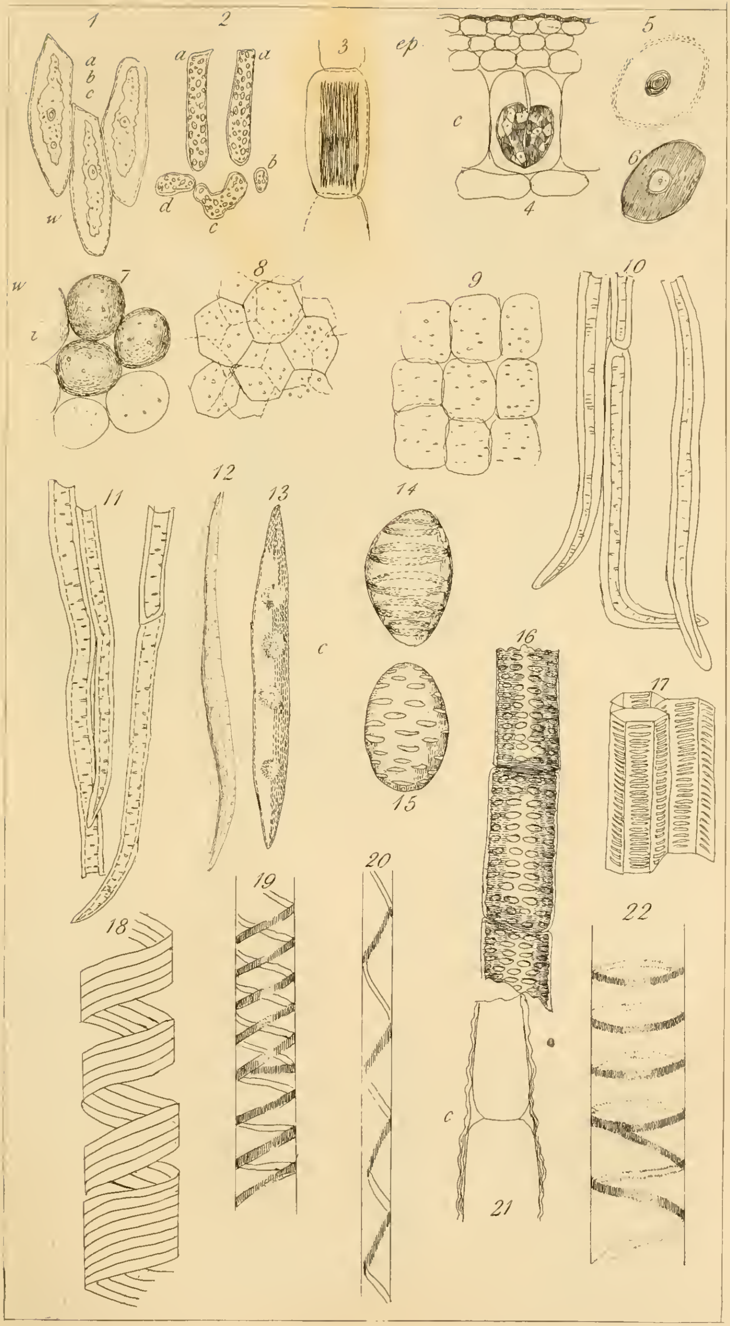
London Published by John Van Voorst Paternoster Row 18[illegible]

FORMS OF LEAVES.—VENATION

London Published by John Van Voorst Paternoster Row 1858

FORMS OF LEAVES.—VENATION

Published by John Van Voorst Paternoster Row

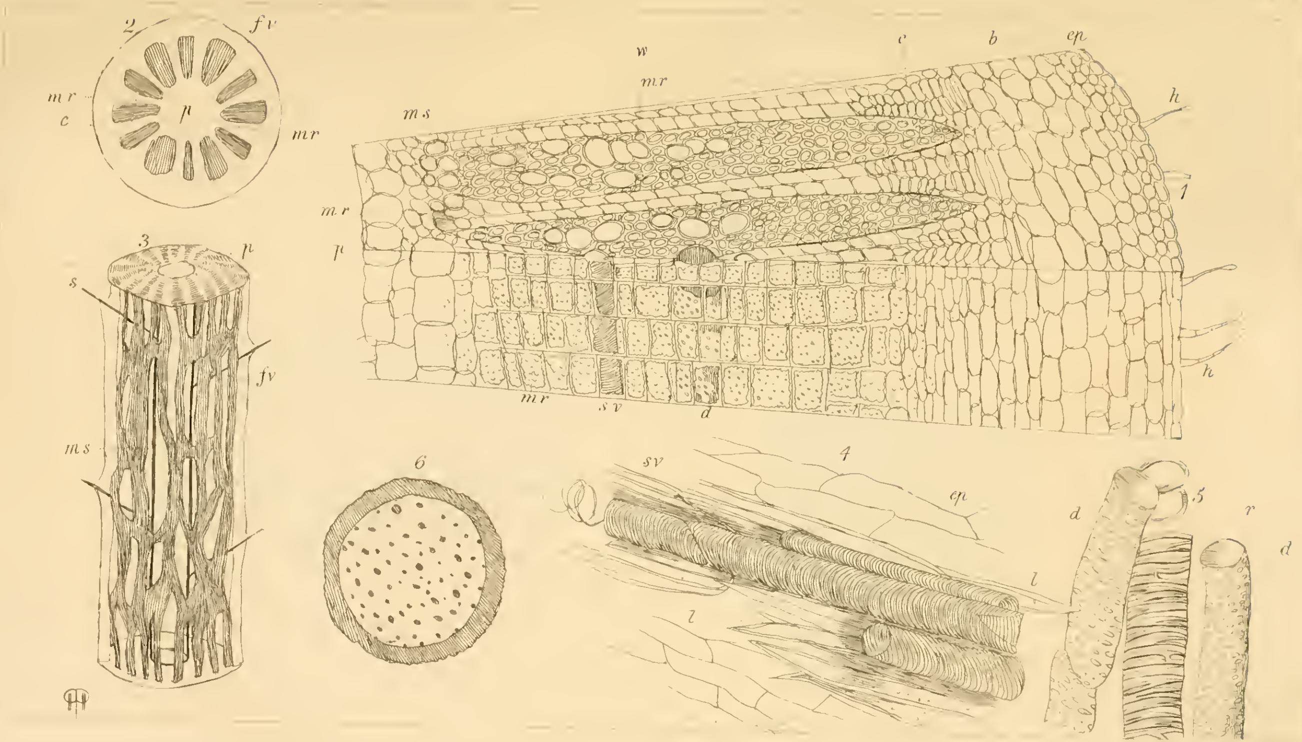


VEGETABLE CELLS AND VESSELS

London Published by John Van Voorst Paternoster Row

SEEDS _ ROOTS _ STEM

London Published by John Van Voorst Paternoster Row

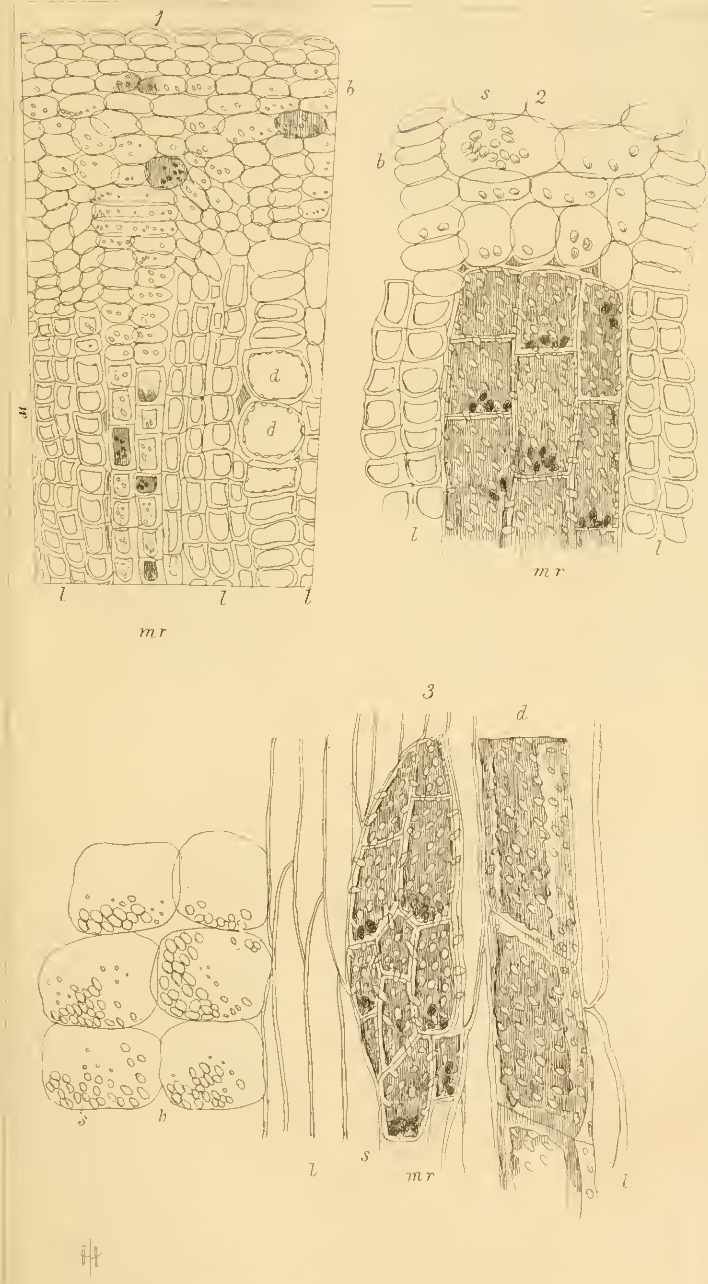


STEMS

LEAF _ VEIN

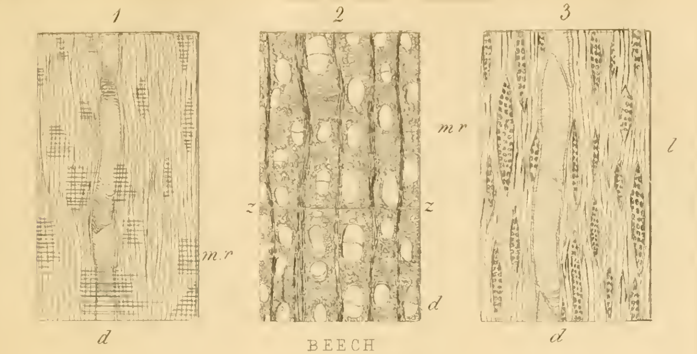
VESSELS.

London Published by John Van Voorst Paternoster Row 1858

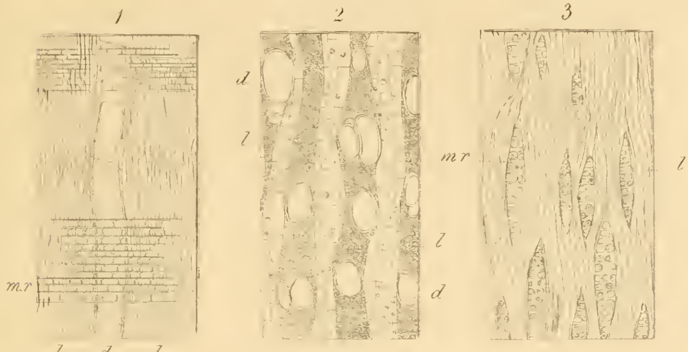


TOBACCO_STEM

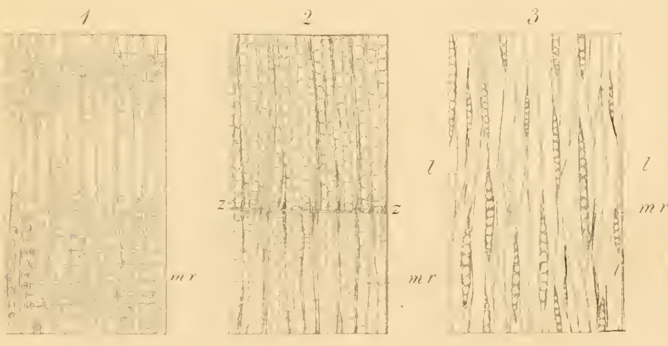
London Published by John Van Voorst Patern[illegible] Row 1858



BEECH



MAHOGANY

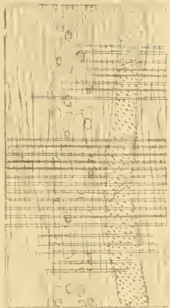


PINE.

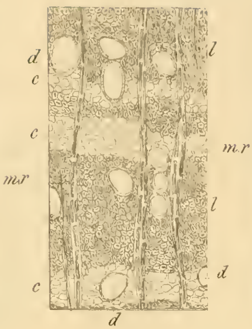
WOOD

LOGWOOD

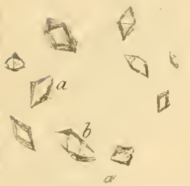
1



2



3



4

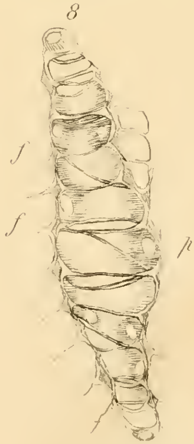
5

6

7

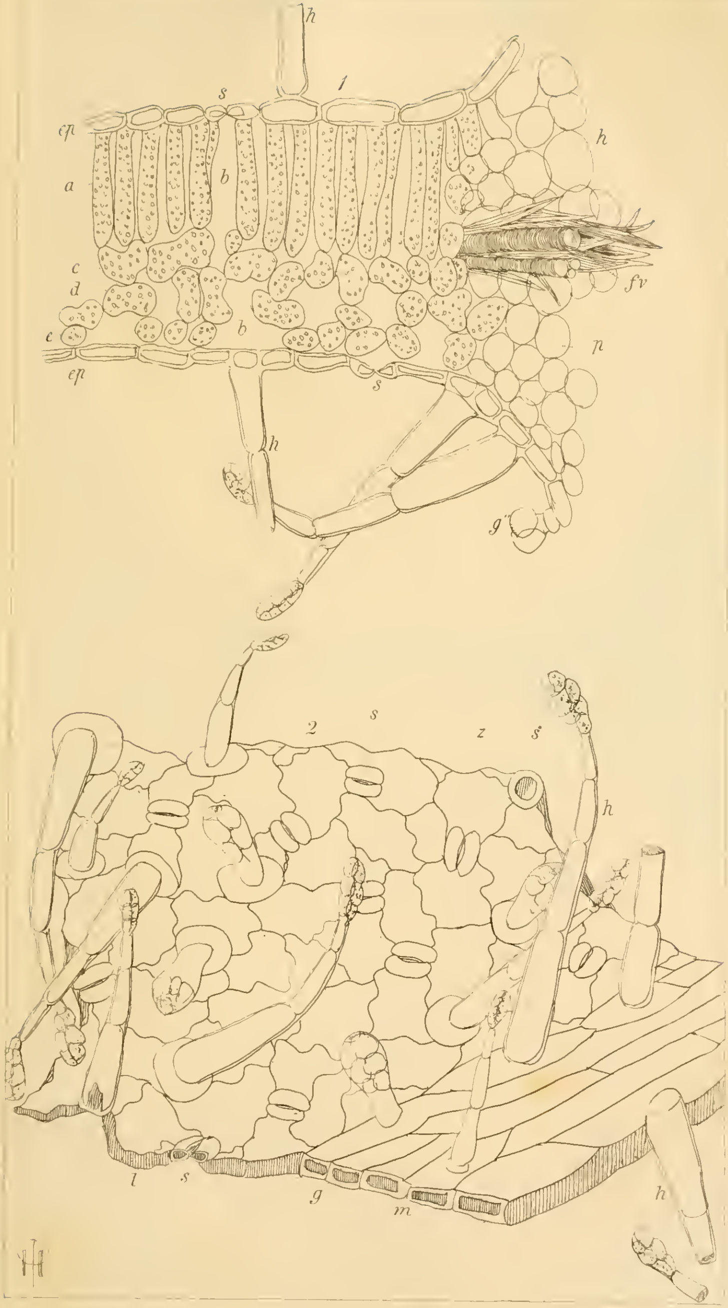
LEAF OF PEAT-MOSS

8



SINGLE CELL OF LEAF

TOBACCO LEAVES



TOBACCO-LEAF

London Published by J hn. Van Voorst Paternoster Row 1859

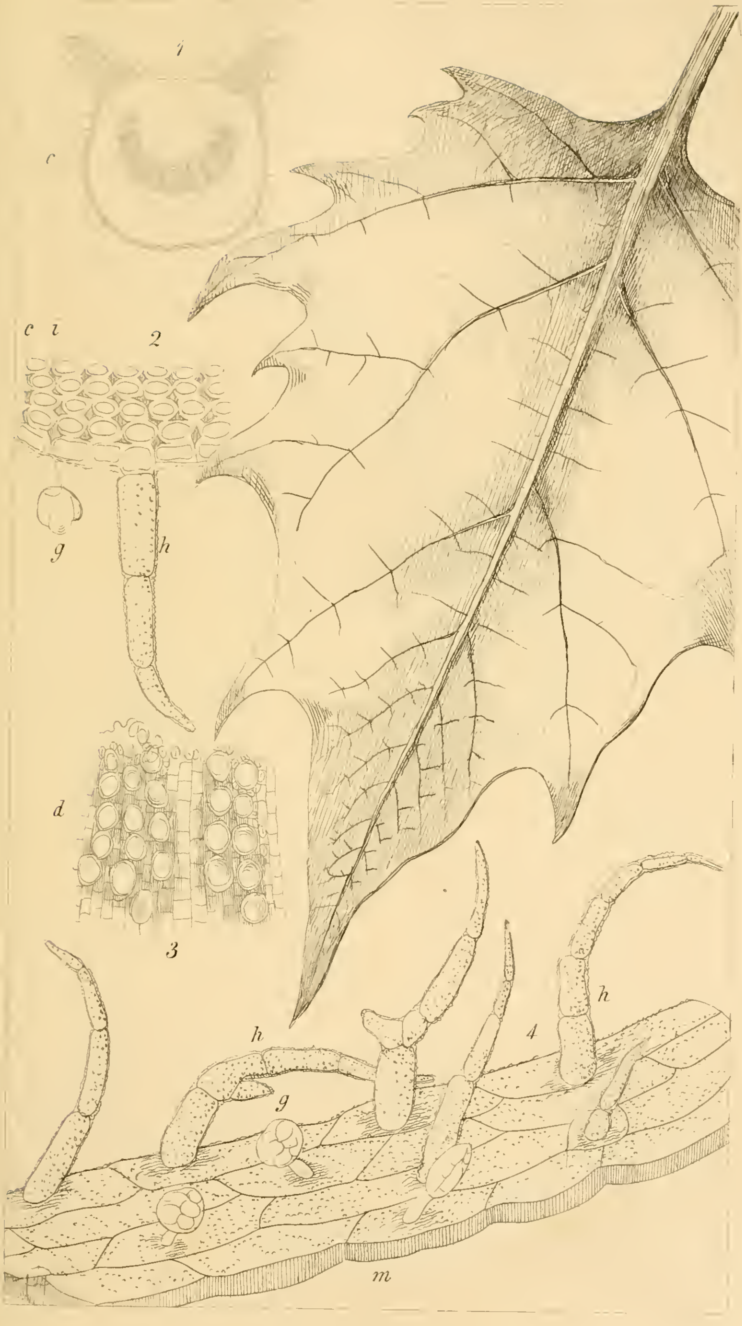
TOBACCO (PURE.)

TOBACCO (ADULTERATED)

London, Published by John Van Voorst, Paternoster Row 1855

THORN-APPLE

London Published by John Van Voorst Paternoster Row 1858



THORN_APPLE.

London Published by John Van V[illegible] Paternoster Row [illegible]

DEADLY_ NIGHTSHADE

London Published by John Van Voorst Paternoster Row 1858

POTATO

London Published by John Van Voorst Paternoster Row 1858

COLTSFOOT BURDOCK MULLEIN. BUTTERBUR

London Published by John Van Voorst Paternoster Row 1858.

BURDOCK

BUTTERBUR

Lond: Published by John Van Voorst Paternoster Row

BASES OF LEAVES

COLTSFOOT

CHICORY

London Published by John Van Voorst Paternoster Row 185

DANDELION

SUNFLOWER

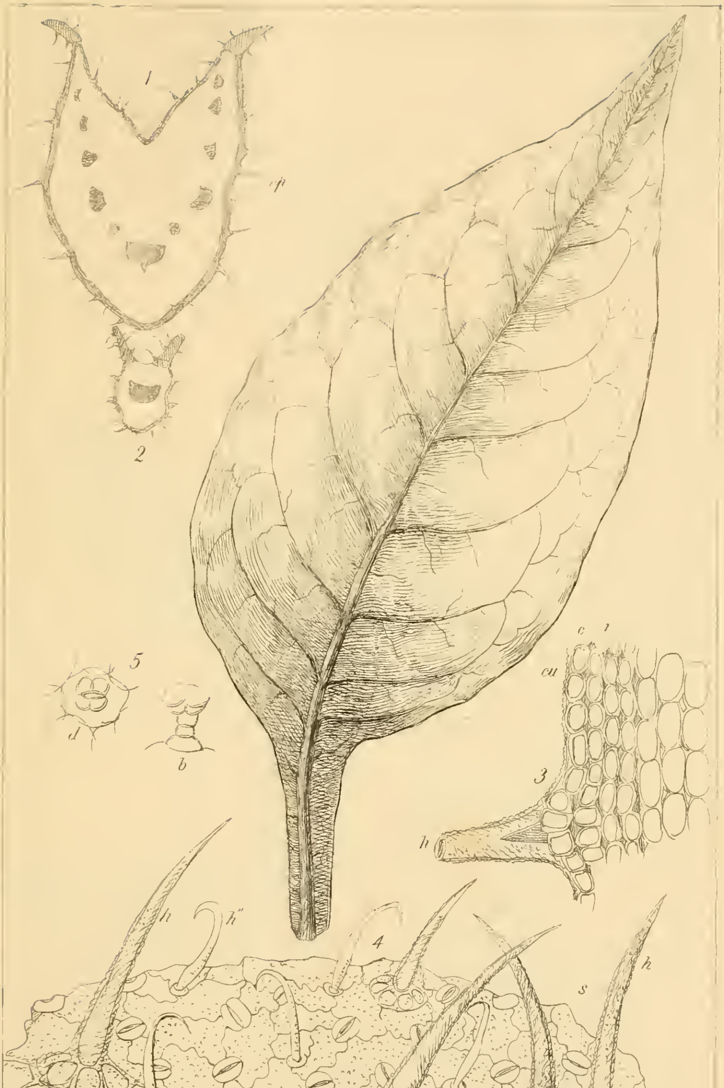
London Published by John Van Voorst Paternoster Row 1858

ELECAMPANE

London, Published by John Van Voorst, Paternoster Row 18[illegible]

COMFREY — RHUBARB

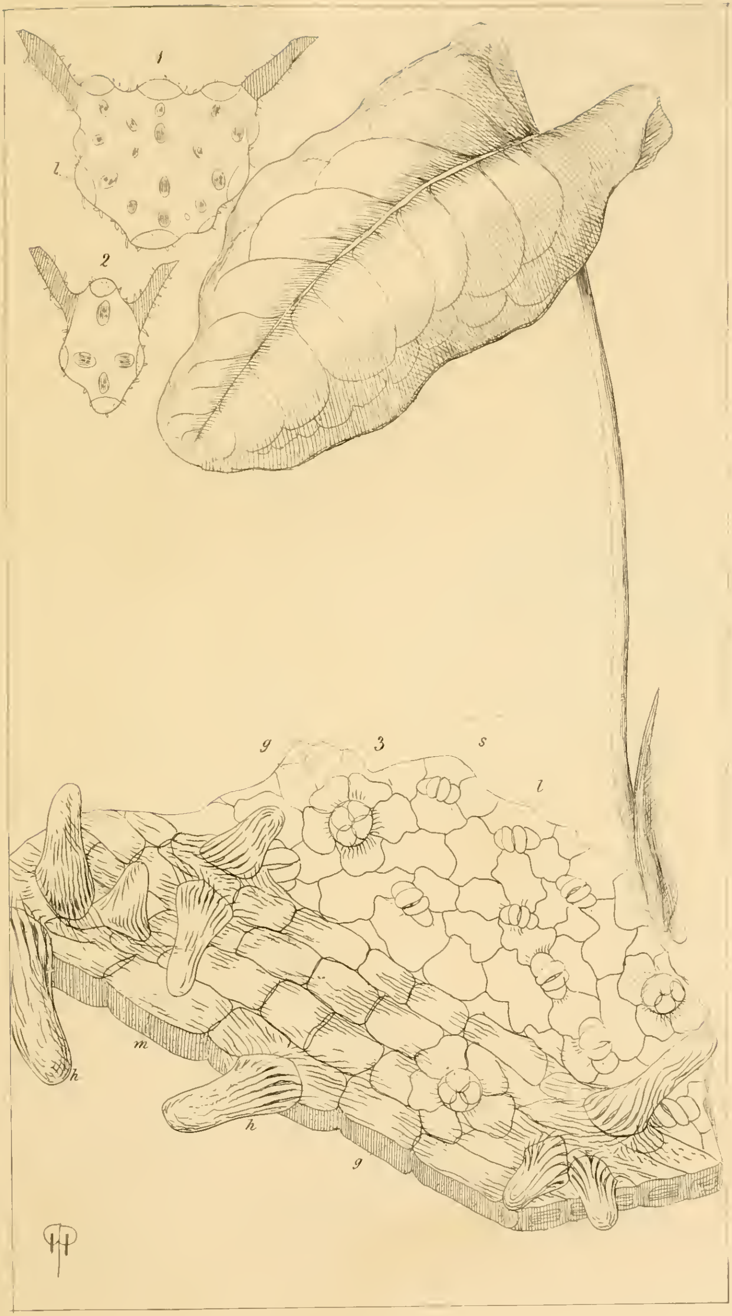
London [illegible]



COMFREY

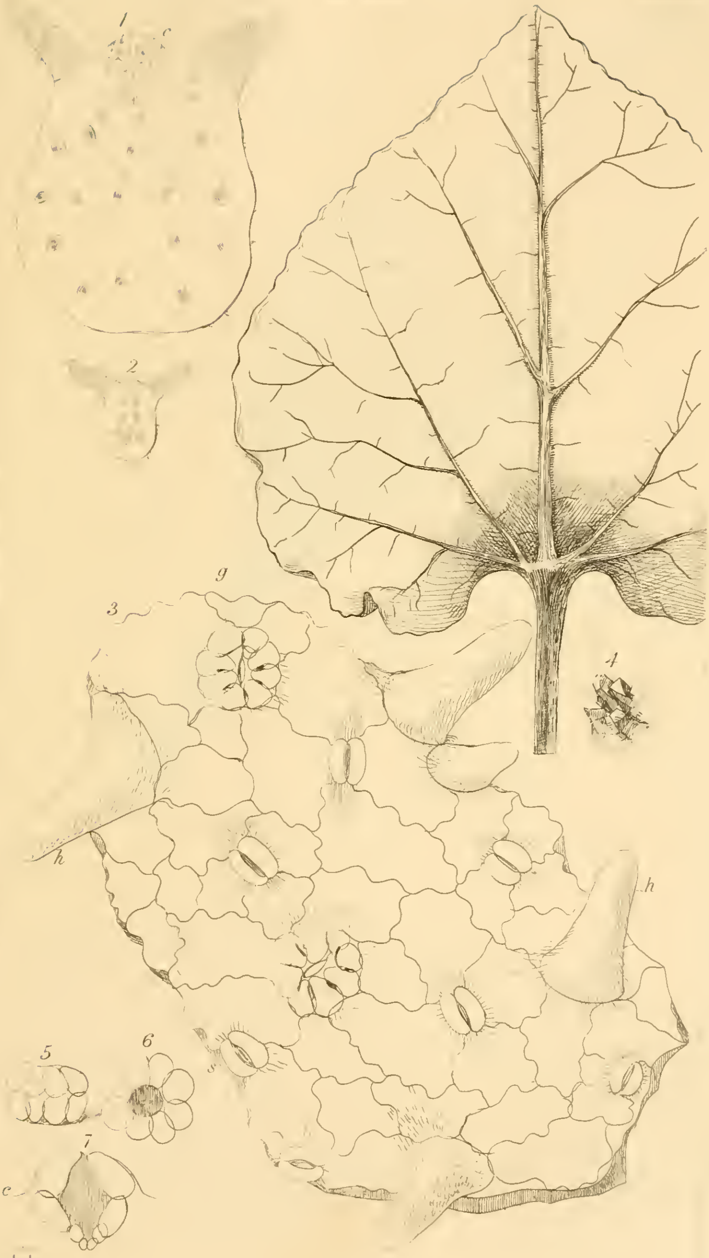
London Published by John Van Voorst Paternoster Row 1858

DOCK.—PLANTAIN.



DOCK

London Published by John Van Voorst Paternoster Row 1858

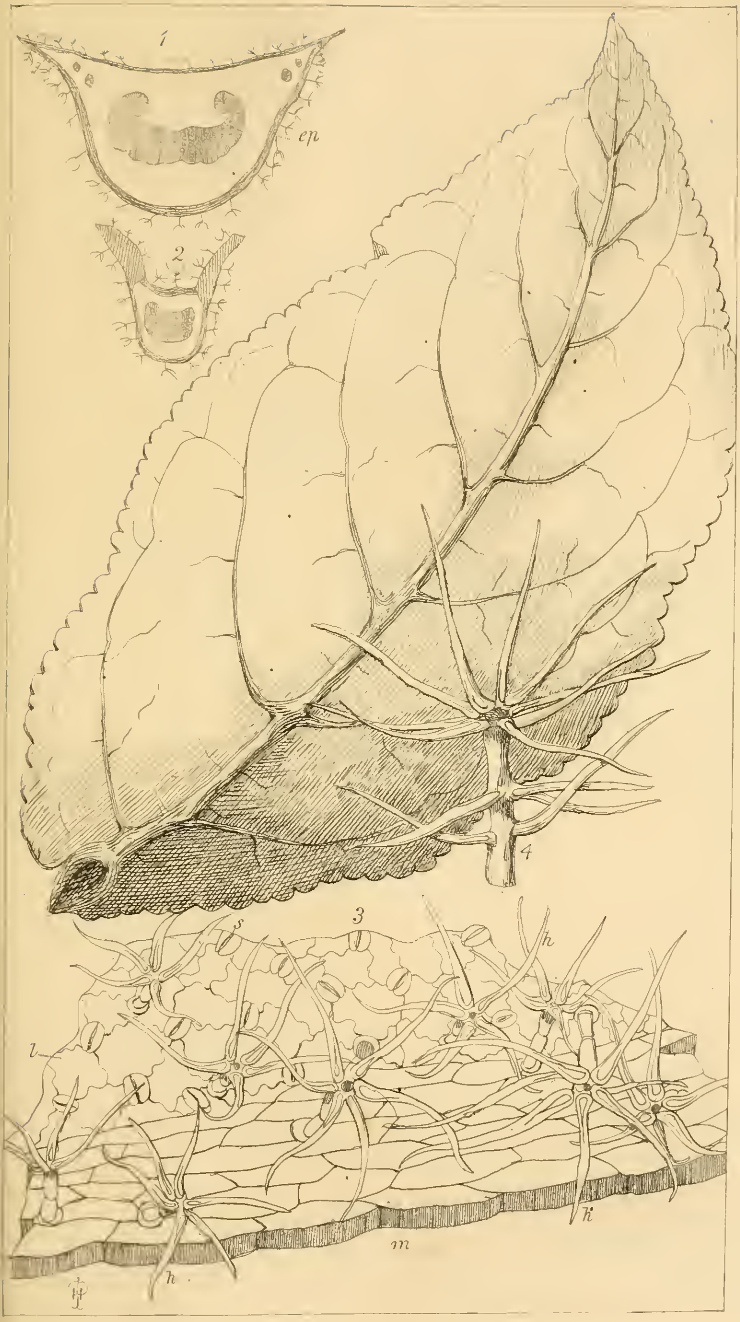


RHUBARB

London, Published by John Van Voorst, Paternoster Row

FOXGLOVE

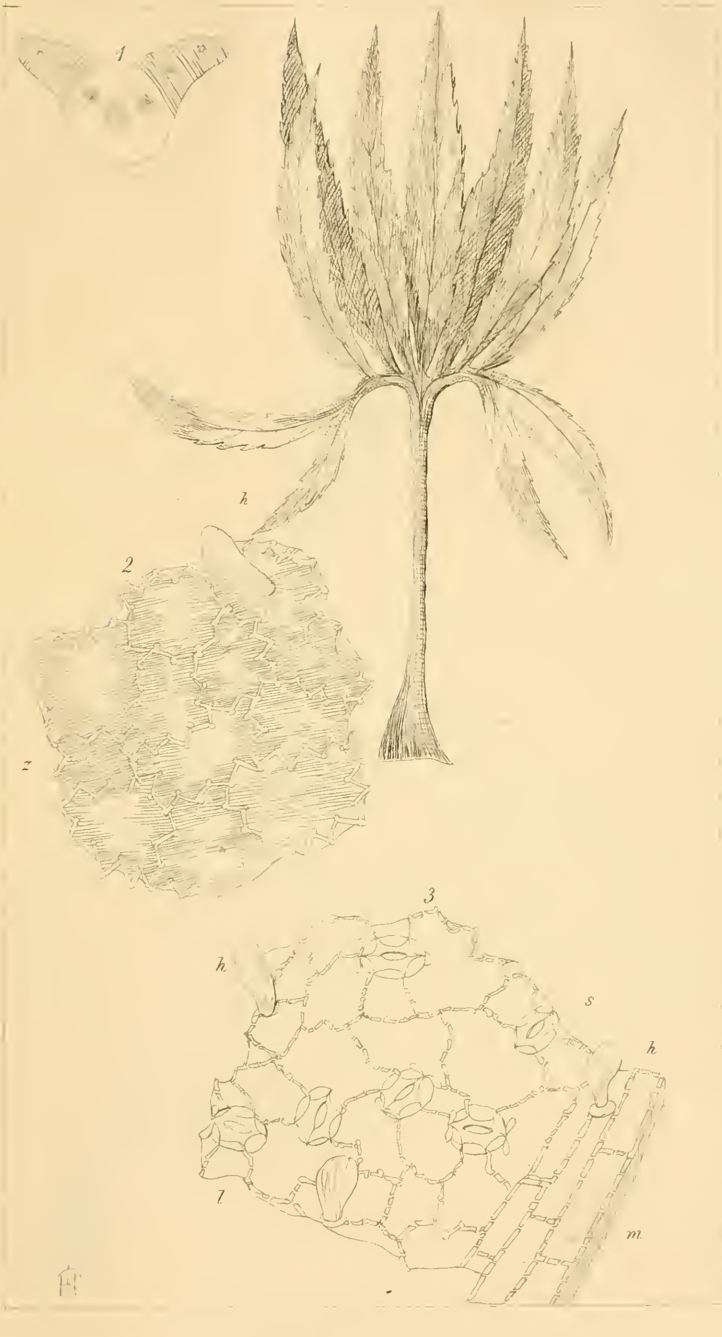
London Published by John Van Voorst Paternoster Row 1858



MULLEIN

GREEN HELLEBORE

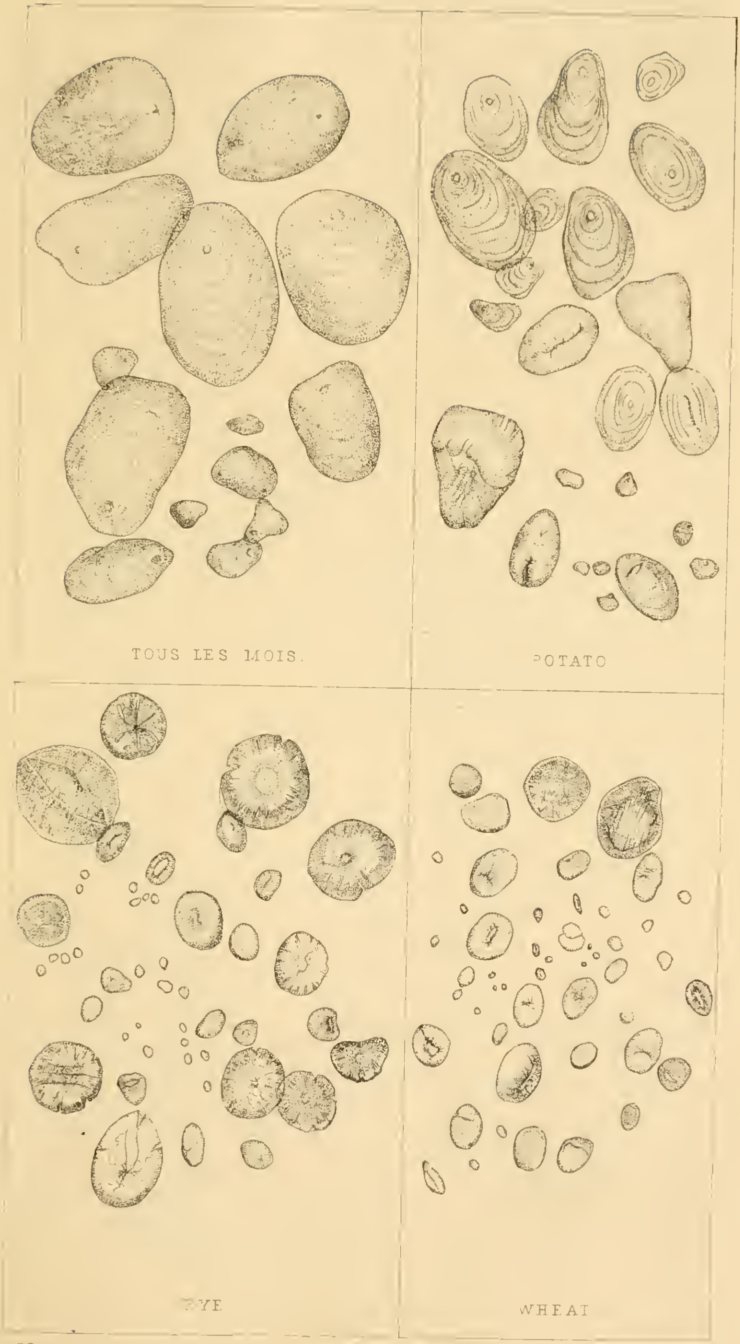
London Published by John Van Voorst Paternoster Row 1858



STINKING HELLEBORE

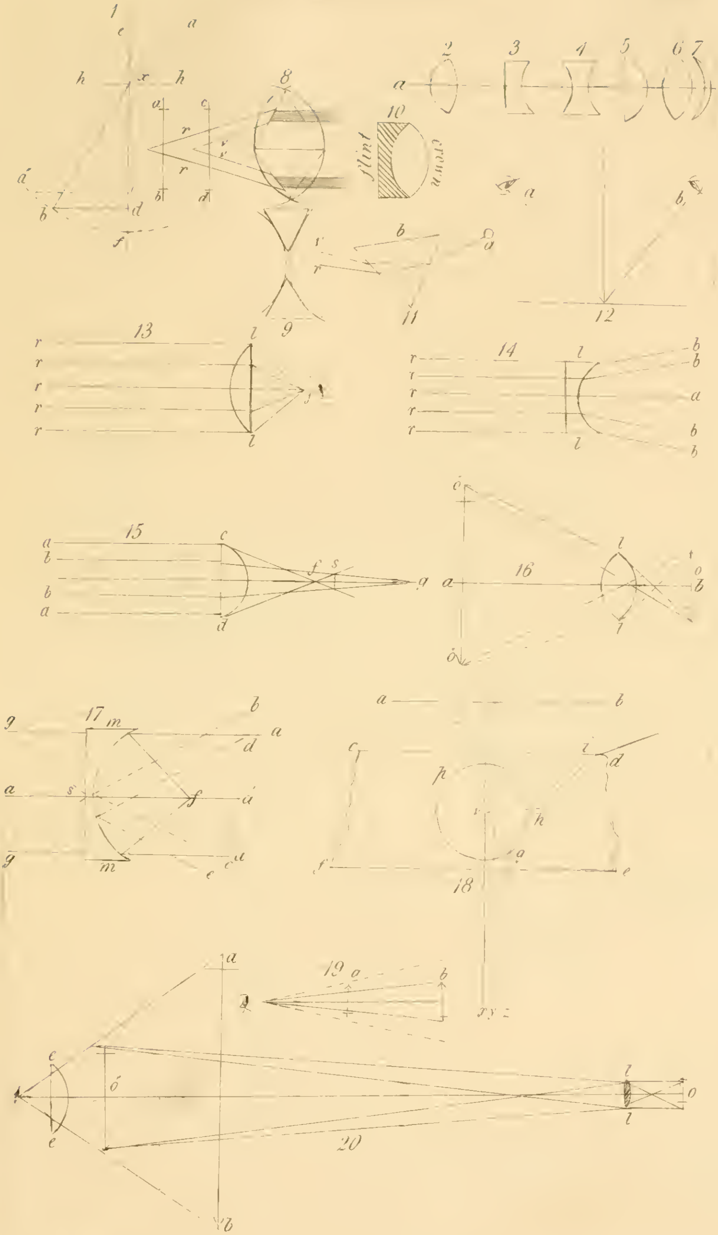
PLANTAIN

London, Published by John Van Voorst Paternoster Row 1858

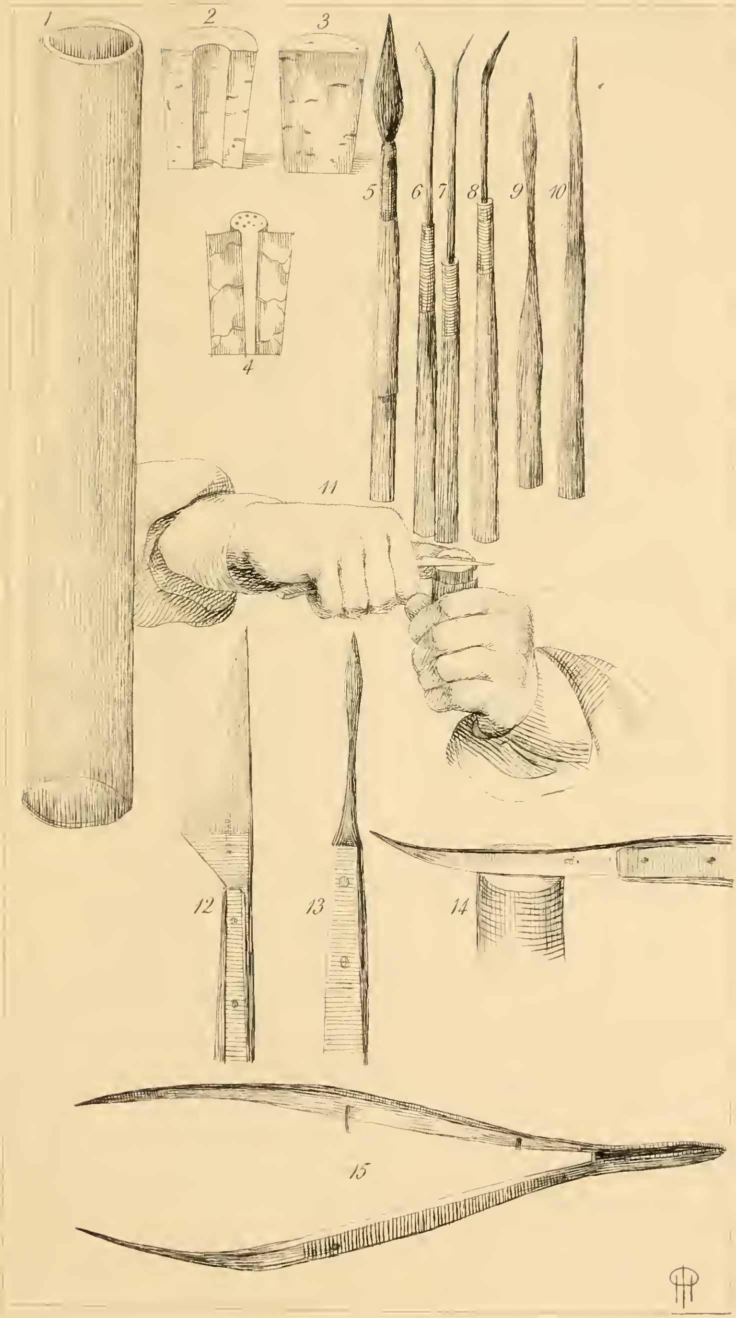


STARCHES

STARCHES



THE MICROSCOPE


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15